



CHINA CLASSIFICATION SOCIETY

**BULK CARRIERS - GUIDELINES FOR SURVEYS,
ASSESSMENT AND REPAIR OF HULL
STRUCTURES
2014**

Implementation date: July 1, 2014

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1. Introduction

This guidelines provides for a bulk carrier type ship which is constructed with a single deck, double bottom, hopper side tanks and topside Tanks, single or double skin in cargo spaces area, and is intended primarily to carry dry cargo, including ore in bulk, with the intention of giving guidelines to assist ship's owner, surveyors of class, and other interested parties involved in the survey, assessment and repair of hull structures for bulk carrier.

The guidelines focus on the survey procedures of China Classification Society (Hereinafter referred to as CCS) but may also be useful in connection with inspection/examination schemes of other regulatory bodies, owners and operators.

The guidelines includes some basic knowledge about bulk carrier such as ship type introduction and CCS survey procedures of class and other relevant requirements, and the preparation necessary before the surveys be carried out and all kinds of periodic surveys.

The guidelines encompasses the different main structural areas of the hull where damages have been recorded, focusing on the main features of the structural items of each area.

The guidelines involves structure failures, examples of damaged structures, potential causes, survey points to be carried out and recommended repairing for each structural area based on IMO Resolution A.866(20).

The guidelines is written according to the collected relevant information and is only intended to provide the guidance to the related parties to make technical decisions. In case of detailed technical issues, it is to be in compliance with the the professional experience of the surveyors. Neither the corresponding requirements of the international Conventions nor CCS Rules could be replaced by the guidelines.

2. Ship Type Introduction of Bulk Carrier

2.1 Bulk carrier means a ship which is constructed generally with single deck, double bottom, top-side tanks and hopper side tanks, single skin or double skin in cargo spaces, and is intended primarily to carry dry cargo in bulk, and includes such types as ore and combination carriers. “Bulk Carrier” which isn’t specially referred to double-skin generally means the single skin bulk carrier. Figure 2(1) & 2(2) show the general view of a typical single or double skin bulk carrier.

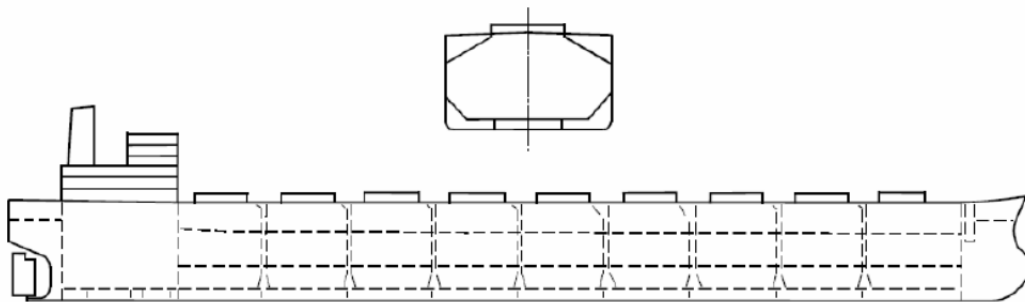


Figure 2 (1) Single skin bulk carrier

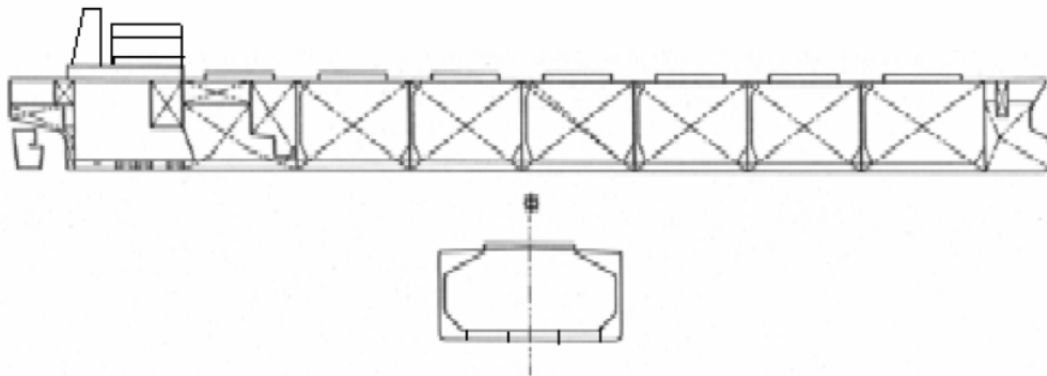


Figure 2 (2) Double skin bulk carrier

2.2 Bulk carrier defined in the guidelines is different from the definition in Article 1.1 in SOLAS Chapter XII which has been revised by MSC.170(79). The definition in SOLAS Reg. XII/1.1 is “Bulk carrier means a ship intended primarily to carry dry cargo in bulk, and includes such types as ore carriers and combination carriers”, which does not include the structure type requirements. Therefore, for the ship carrying cargo in bulk when is required to meet the requirements of the SOLAS, more attention is to be paid to Resolution MSC.277(85) “Clarification of the Term ‘Bulk Carrier’ and Guidance for Application of Regulations in SOLAS to Ships Which Occasionally Carry Dry Cargoes in Bulk and are

not Determined as Bulk Carriers in Accordance With Regulation XII/1.1 and Chapter II-1.”

2.3 In general, bulk carrier can be categorized as Handysize bulk carrier, Panamax bulk carrier, Capesize bulk carrier, VLOC (Very Large Ore Carrier), Great Lakes bulk carrier according to its navigation route and deadweight,

1) Handysize bulk carrier is a ship with the capacity of deadweight between 20,000~50,000 tons. The ship with deadweight exceeding 40,000 tons is called Handymax bulk carrier. This kind of bulk carrier has strong adaptability to the sea-route, rivers and ports.

2) Panamax bulk carrier is the largest ship of all which can pass the Panama Canal in full load condition, and mainly meet the provision of overall length less than 274.32 meters and breadth not exceeding 32.31 meters. If necessary, adjusting the ship's principal dimensions, ship's type and hull structures with the general deadweight between 55,000~85,000 tons. The kind of bulk carrier with deadweight between 50,000~54,999 tons is called Baby-PanamaxBulkers and called Supramax Bulkers if the deadweight of which is between 50,000~64,999 tons. If the overall length exceeds 229 meters, the bulk carrier is called KAMSAR Type bulk carrier. With the widening of the Panama Canal, size of panama bulk carrier will be bigger.

3) Capesize bulk carrier: This kind of bulk carrier is mainly for iron ore transportation with deadweight range from 120,000 tons to 210,000 tons. Due to the dimension restriction of Panama Canal and Suez Canal, the lane needs to pass Capesize and Cape Horn. The intermediate deadweight is divided into following kinds:

Handy-cape Bulklers: Deadweight not exceeding 119,999 tons, moulded breadth over 39.5m.

Post Panamax Bulklers: Deadweight range from 50,000 tons to 110,500 tons, moulded breadth over 39.5m but not exceeding 39.1m

4) VLOC: This kind of bulk carrier is normally intended for long-distance transportation of coals and iron ore and the deadweight of which is not less than 210,000 tons. Compared with traditional bulk carrier, smaller cargo capacity and hatch are specified.

5) Great Lakes bulk carrier: This kind of bulk carrier is sailing within five Great lake districts of the USA & Canada border through the Saint Lawrence lane which is mainly carrying coal, iron ore and grain. The principle dimension is required to be in accordance with Saint Lawrence lane navigation condition. The overall length of the ship is not to exceed 222.5 m, the moulded breadth is not to exceed 23.16 m, any part of the bridge is not to extend over the hull, the draught is not to exceed the maximum allowable draught and the distance from the mast top to the waterline is not to exceed 35.66m. The deadweight is normally around 30,000

tons, mostly equipped with cargo lifting equipment.

3. Hull Structural Survey of Bulk Carrier

3.1 General

3.1.1 Classification survey of ship refers to inspection and test carried out by the classification society or its agent to ship which has been classed or intend to be classed with the society in accordance with scope of survey and requirements of the provisions of classification. The purpose of classification survey is to inspect whether structural strength, propulsion, operation and auxiliary equipment, systems and maintenance condition comply with the related requirements in the provisions of classification.

3.1.2 Special survey or intermediate survey in accordance with the scope of special survey is to be carried out according to the requirements of ESP Code. For the ships assigned with class notation ESP of 20,000 tonnes DWT and above, since the third special survey, all special and intermediate hull classification surveys are to be carried out by at least two surveyors with the ESP qualification at the same time. For the bulk carriers with single side skin construction, between 10 and 15 years of age, and of 100,000 tons DWT and above, the intermediate hull classification survey is also to be performed by two surveyors with the ESP qualification at the same time. The thickness measurement process is to be controlled by a professional surveyor onboard where necessary.

3.1.3 The ESP is based on two principal criteria: the condition of the coating and the extent of structural corrosion. Of primary importance is when a coating has been found to be in a “poor” condition (more than 20% breakdown of the coating or the formation of hard scale in 10 % more of the area or more than 50% local breakdown of the coating or rust on edges or weld lines) or when a structure has been found to be substantially corroded (i.e. a wastage between 75 % and 100 % of the allowable diminution for the structural member in question.).

3.1.4 From 1991, the protective coating is to be applied to the internals of water ballast tanks, with parts formed the boundaries of the hull. From 1993, the aforesaid requirements were applicable to the side shell structures and transverse bulkhead structures which are within the cargo area. The effective corrosion prevention of all dedicated seawater ballast tanks arranged in oil tankers and bulk carriers constructed on or after 1 July 1998, is to comply with the requirements of Guidelines for the Selection, Application and Maintenance of Corrosion Prevention System of Dedicated Seawater Ballast Tanks set

forth in IMO Resolution A.798(19). For international sea-going ships of 500 gross tonnage or above, with the construction contracts signed on or after 1 July 2008 (those without a construction contract, and keel laying on or after 1 January 2009 or in similar construction stage; or ships delivered on or after 1 July 2012), the coating in way of the dedicated seawater ballast tanks and double-side skin spaces of bulk carriers of 150m in length or above is to be in compliance with the requirements of Performance Standard for Protective Coatings for Dedicated Seawater Ballast Tanks in All Types of Ships and Double-side Skin Spaces of Bulk Carriers (PSPC Standard). Bulk carriers of 90 m in length or above and oil tanks of 150 m in length or above with the construction contracts signed on or after 8 December 2006 and constructed in accordance with IACS Common Structure Rules are also to comply with the PSPC Standard.

3.1.5 For bulk carriers of 150m in length and upwards with single deck & top side tank & bottom side tank construction, carrying solid bulk cargoes having a density of $1,780\text{kg/m}^3$ and above, with watertight corrugated transverse bulkhead between No.1 and No.2 cargo hold not subject to URS18 (URS:IACS uniform requirement of structural strengthen, same as below), the construction contracts of which was signed on or before 1 July 1998, the assessment in accordance with IACS URS 19,22 and S23 is not to be later than the required date of URS23. The corrugated transverse bulkhead between No.1 and No.2 cargo hold is to be checked in accordance with the assessment results of URS19 since the third special survey and subsequent special survey & intermediate survey.

3.1.6 For single-hull bulk carriers which is not subject to the requirements of URS12 (the construction contract was signed on or before 1 July 1998), the top & bottom brackets of cargo hold frame are to be assessed in accordance with the requirement of URS31. The top & bottom brackets of cargo hold frame are to be checked in accordance with the requirements of URS31 since the second special survey and subsequent special survey & intermediate survey.

3.1.7 Bulk carriers of 90m in length and upwards, the construction contract of which was signed on or after 1 March 1998, are to be designed and constructed in accordance with the IACS Common Structural Rule for Bulk Carrier (CSR), the substantial corrosion range of steel structure is $t_{\text{ren}} + 0.5\text{mm}$ and t_{ren} .

3.1.8 During the annual survey, the intermediate survey and renewal survey and any other surveys having the similar inspection scope, thickness measurements of structure members in the area of close-up inspection is to be carried out together with close-up inspection.

3.2 Definitions

3.2.1 As the reference of structural terms adopted by the guidelines, picture 3.2(1) shows the typical structural arrangements of cargo area. In addition to, picture 3.2(2), 3.2(3) and 3.2(4) show the typical transverse section and typical longitudinal section of watertight transverse bulkhead in the cargo holds. The general structural terms are given on the above pictures. For the purpose of reporting the definition and survey information correctly, it is suggested to use standard terms. The definitions of this guidelines are indicated as following:

3.2.2 A ballast tank is a tank which is used solely for salt water ballast, or, where applicable, a space which is used for both cargo and salt ballast will be treated as a ballast tank when substantial corrosion has been found in that space.

3.2.3 Spaces are independent compartments, including holds, tanks, cofferdams and void spaces bounding cargo holds, decks and the outer hull.

3.2.4 Overall survey means surveys intended to report on the complete conditions of the hull structure and to define the scope of close-up surveys.

3.2.5 A close-up survey is a survey where the details of structural components are within the close visual inspection range of the surveys, i.e. normally within reach of hand.

3.2.6 A transverse section of a bulk carrier includes all longitudinal members such as plating, longitudinals and girders at the deck, sides, bottom, inner bottom, hopper sides, longitudinal bulkheads and bottom in top wing tanks. For transversely framed vessels, a transverse section includes adjacent frames and their end connections in way of transverse sections.

3.2.7 Representative spaces are those which are expected to reflect the conditions of other spaces of similar type and service and with similar corrosion protection systems. When selecting representative spaces, account is to be taken of the service and repair history on board and identifiable critical and/or suspect areas.

3.2.8 Suspect areas are locations showing substantial corrosion and/or considered by the Surveyor to be prone to rapid wastage.

3.2.9 Substantial corrosion is an extent of corrosion such that assessment of corrosion pattern indicates a wastage in excess of 75% of allowable margin, but within acceptable limits. For CSR ships, substantial corrosion is an extent of corrosion such that assessment of the corrosion pattern indicates a gauged (or

measured) thickness between $t_{net}+0.5\text{mm}$ and t_{net} .

- 3.2.10 Corrosion Prevention System is normally considered a full hard coating, a full hard coating is usually to be epoxy coating or equivalent.

Other coating systems such as soft coating or semi-hard coating may be considered acceptable as alternatives provided that they are applied and maintained in compliance with the manufacturer's instructions.

- 3.2.11 Coating condition is defined as follows:

GOOD: condition with only minor spot rusting.

Fair: condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for POOR condition.

POOR: condition with general breakdown of coating over 20% or more of area or hard scale at 10% or more of areas under consideration or more than 50% local breakdown of the coating or rust on edges or weld lines.

- 3.2.12 Transition Region is a region where discontinuity in longitudinal structure occurs, e.g. at forward bulkhead of engine room and collision bulkhead.

- 3.2.13 Cargo area is that part of the ship which includes all cargo holds and adjacent areas including fuel tanks, cofferdams, ballast tanks and void spaces.

- 3.2.14 Special consideration: (in connection with close-up survey and thickness measurement): means sufficient close-up inspection and thickness measurements are to be taken to confirm the actual average condition of the structure under the coating.

- 3.2.15 Critical Structural Areas are locations which have been identified from calculations to require monitoring or from the service history of the subject ship or from similar ships to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the ship.

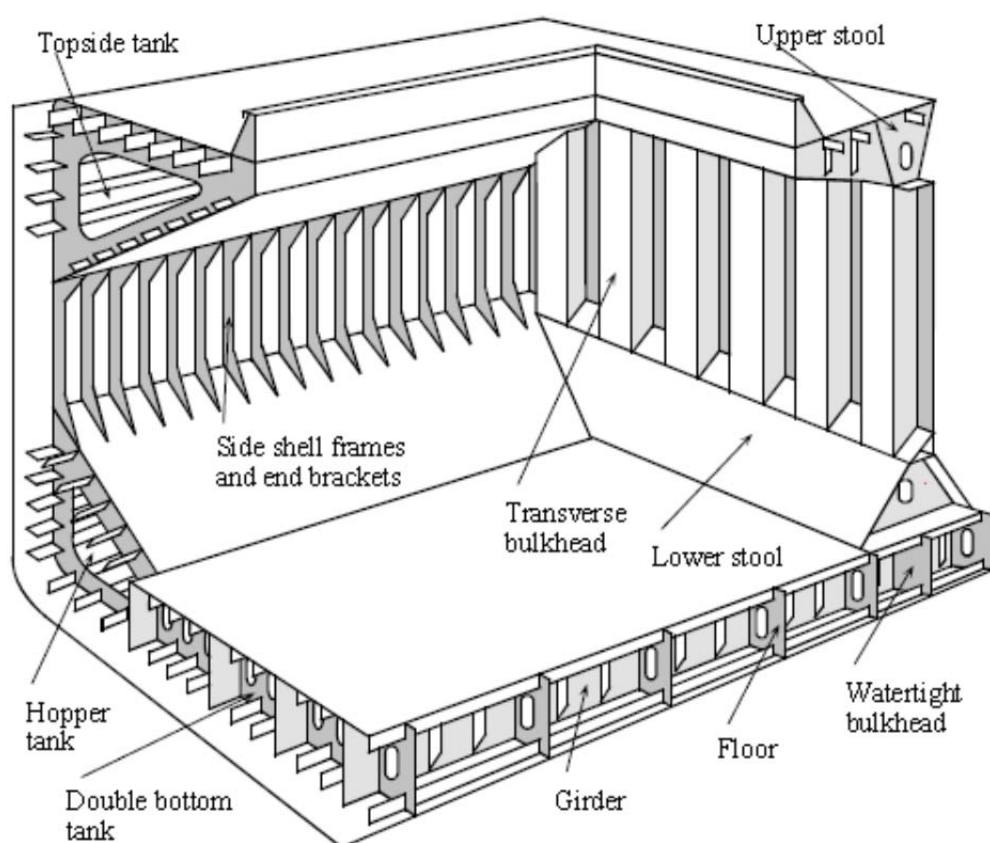


Figure 3.2 (1) Typical cargo hold configuration for a single skin bulk carrier

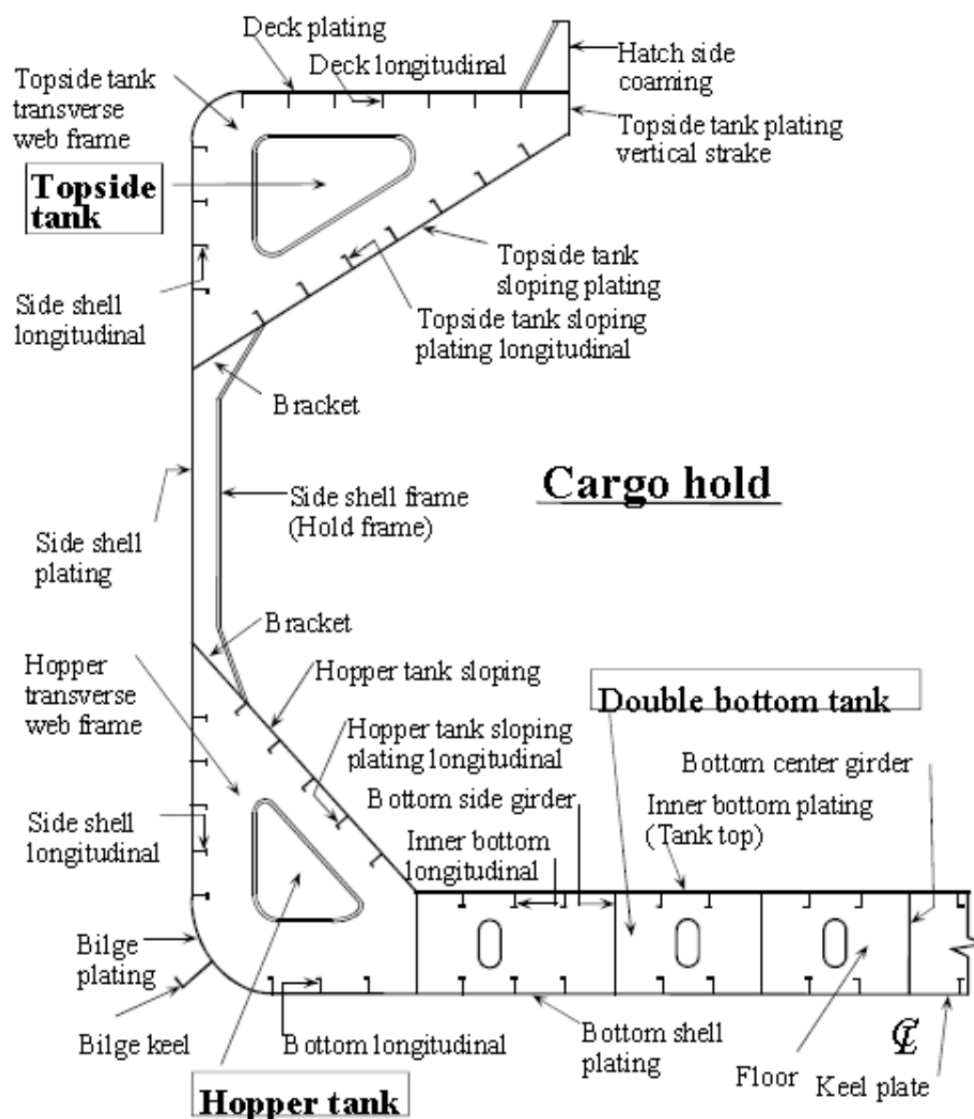


Figure 3.2 (2) Nomenclature for typical transverse section in way of cargo hold

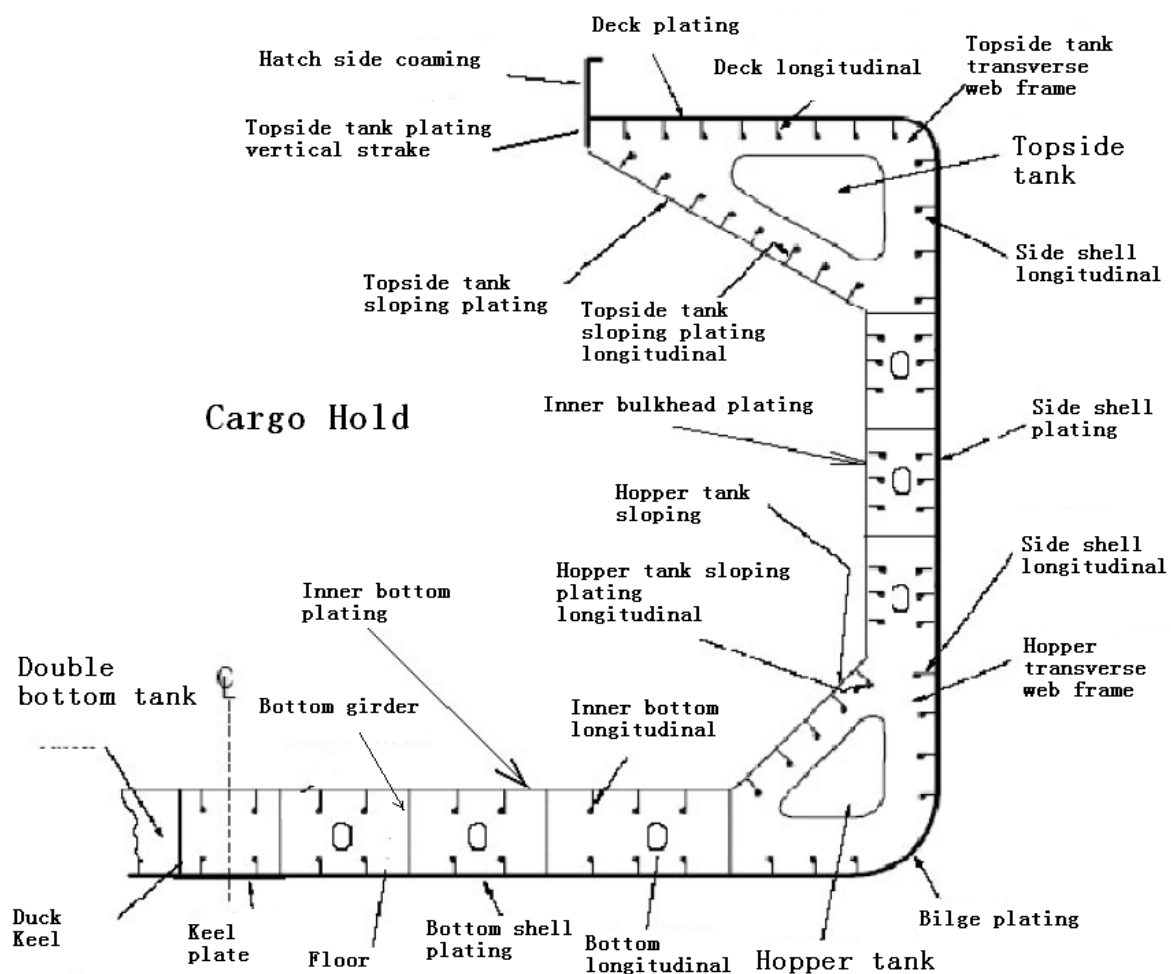


Figure 3.2 (3) Nomenclature for typical transverse section in way of cargo hold of double skin bulk carrier

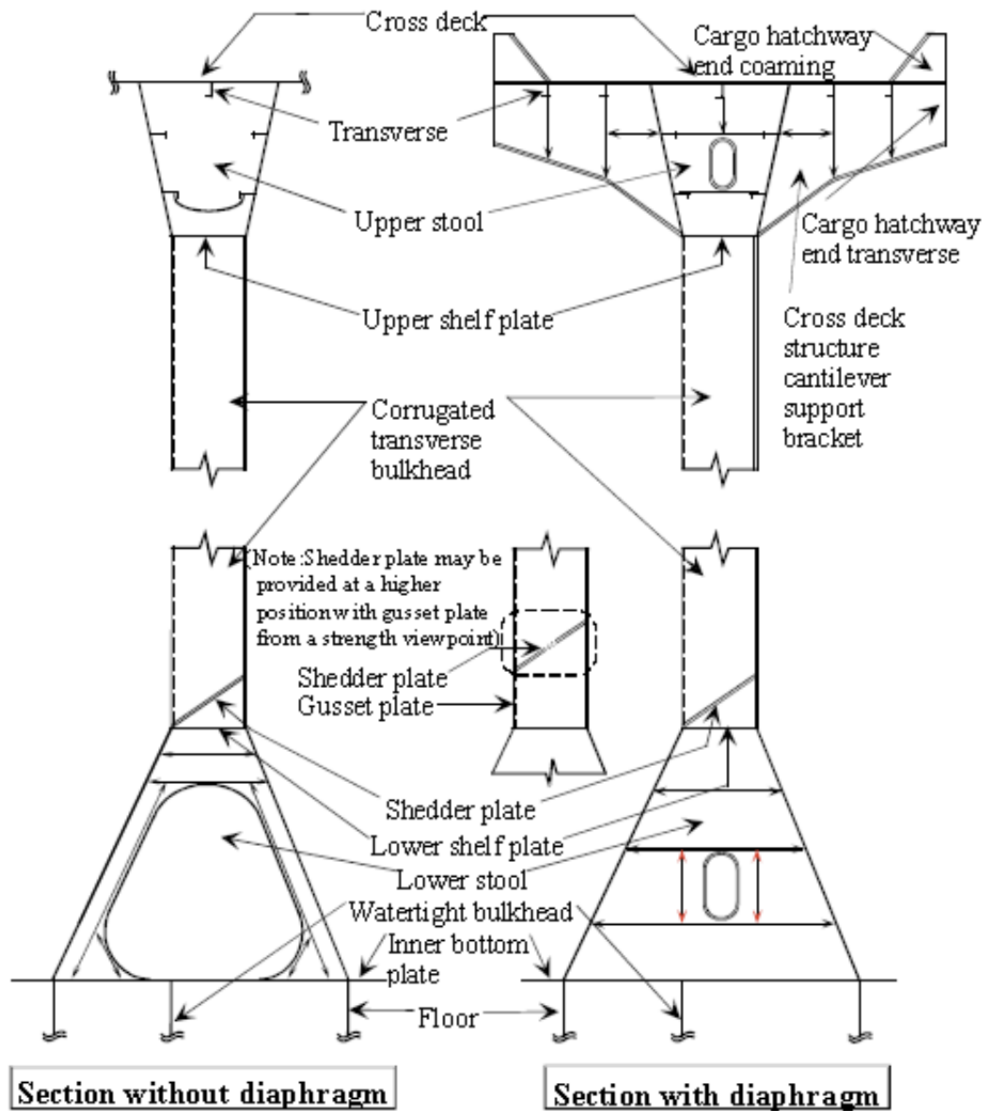


Figure 3.2 (4) Nomenclature for typical watertight bulkhead

3.3 Preparations for survey

3.3.1 Conditions for survey

3.3.1.1 Before the survey, cargo holds, liquid tank or other spaces need to be fully degasified and properly ventilated. Oxygen and gas detection is also required when entering the liquid tank, void space or other closed space, to ensure there is no harmful air and proper oxygen content.

3.3.1.2 In preparation for survey and thickness measurements and to allow for a thorough examination, all spaces are to be cleaned including removal from surfaces of all loose accumulated corrosion scale. Spaces are to be sufficiently clean and free from water, scale, dirt, oil residues etc. to reveal corrosion,

deformation, fractures, damages, or other structural deterioration. However, those areas of structure whose renewal has already been decided by the owner need only be cleaned and descaled to the extent necessary to determine the limits of the renewed areas.

3.3.1.3 Sufficient illumination is to be provided to reveal corrosion, deformation, fractures, damages or other structural deterioration

3.3.1.4 Where soft coatings have been applied, safe access is to be provided for the Surveyor to verify the effectiveness of the coating and to carry out an assessment of the conditions of internal structures which may include spot removal of the coating. When safe access cannot be provided, the soft coating is to be removed.

3.3.1.5 In addition, particular attention is to be given to the following guidance::

1) Prior to entering tanks and other closed spaces, it is necessary to ensure that the oxygen content is to be tested and confirmed as safe. When conducting internal survey of the compartment and closed space, the Surveyor will be always accompanied by one designed by the ship owner and experienced in operations inside the compartment and closed space. A team of at least two experienced operators will be assigned at the gate in case of emergency. They are required to keep constant observation of the conditions inside the compartment and closed space to ensure the emergency system is available at any time. Surveyor of cargo hold, liquid tank and other spaces will keep proper communication with the crew on deck or the navigational bridge until the completion of survey.

2) In tanks where the structure has been coated and recently deballasted, a thin slippery film may often remain on the surfaces. Care will be taken when inspecting such spaces.

3) The removal of scale may be extremely difficult. The removal of scale by hammering may cause sheet scale to fall, and in cargo holds this may result in residues of cargo falling from above. When using a chipping or scaling hammer care will be taken to protect eyes, and where possible safety glasses will be worn.

4) If the structure is heavily scaled then it may be necessary to request de-scaling before conducting a satisfactory visual examination.

5) Owners or their representatives have been known to request that a survey be carried out from the top of the cargo during discharging operations. For safety reason, surveys must not to be carried out during discharging operations in the hold.

6) In bulk carriers fitted with vertical ballast trunks connecting the topside and lower hopper tanks, the

trunks and associated hull structure are normally surveyed in conjunction with the tanks. Space within the trucks is very limited and access is by ladder or individual rungs which can become heavily corroded and in some cases detached or missing. Care needs to be taken when descending these trunks.

7) When entering a cargo hold or tank the bulkhead vertical ladders are to be examined prior to descending to ensure that they are in good condition and rungs are not missing or loose. If holds are being entered when the hatch covers are in the closed position, then adequate lighting is to be arranged in the holds. One person at a time is to descend or ascend the ladder.

8) Sloping (“Australian Style”) bulkhead ladders are prone to cargo handling damage and it is not uncommon to find platforms and ladders in poor condition with rails and stanchions missing or loose.

9) If a portable ladder is used for survey purposes, the ladder is to be in good condition and fitted with adjustable feet, to prevent it from slipping. Two crew members are to be in attendance in order that the base of the ladder is adequately supported during use. The remains of cargo, in particular fine dust, on the tank top is to be brushed away as this can increase the possibility of the ladder feet slipping.

10) If an extending/articulated ladder (frame walk) is used to enable the examination of upper portions of cargo hold structure, the ladder is to incorporate a hydraulic locking system and a built in safety harness. Regular maintenance and inspection of the ladder are to be confirmed prior to its use.

11) For safety application of the adjustable ladder as mentioned in 9) and 10) in the close-up survey, Generally requirements are not less than the following:

(1) Ship owner will ensure the facilities selected will provide sufficient protective measures to prevent falling-off from high altitude.

(2) Provide instructions on the safety uses of adjustable ladder.

(3) The adjustable ladder is erected in a steady position of proper size, so as to keep the foot holds at a horizontal level. Suspended type of ladder is to be fixed by a certain way to ensure the ladder will not be displaced or swayed;

(4) Prevent the slipping of adjustable ladder’s footing with the vertical framework, skid prevention system or other equivalent measures fixed near the end.

(5) Adjustable ladder is to meet the following standards:

① Length of independent adjustable ladder is not more than 5 m;

② Self-supporting ladder and non-supporting ladder’s load capacity is at least four times of the

maximum load to bear;

③ Minimum distance from the adjustable ladder's vertical framework will meet the approved standards;

④ Foot hold on the adjustable ladder provides anti-slipping feature (with corrugations, convexes or wrapped with anti-slipping materials)

(6) The ladder is free from grease stains so as to prevent slippery.

12) If a hydraulic arm vehicles ("Cherry Picker") is used to enable the examination of the upper parts of the cargo hold structure, the vehicle is to be operated by qualified personnel and there are to be evidenced that the vehicle has been properly maintained. The standing platform is to be fitted with a safety harness. For those vehicles equipped with a self leveling platform, care is to be taken that the locking device is engaged after completion of maneuvering to ensure that the platform is fixed.

13) Staging is the most common means of access provided especially where repairs or renewals are being carried out. It is always to be correctly supported and fitted with handrails. Flanges are to be free from splits and lashed down. Staging erected hastily by inexperienced personnel is to be avoided. In topside and lower hopper tanks it may be necessary to arrange staging to provide close-up examination of the upper parts of the tank particularly the transverse web frames, especially where protective coatings have broken down or have not been applied.

14) In double bottom tanks there will often be a build up of mud on the bottom of the tank and this is to be removed, in particular in way of tank boundaries, suction and sounding pipes, to enable a clear assessment of the structural condition.

3.3.2 Access to structures

3.3.2.1 For the overall survey, means are to be provided to enable the Surveyor to examine the hull structure in a safe and practical way to inspect the tank.

3.3.2.2 For close-up survey of the hull structure, except the framework in cargo hold, one or more of the following means for access, acceptable to the Surveyor, is to be provided:

- Permanent staging
- Temporary staging and passages through structure
- Lift and movable platforms
- Small boat or raft

- other equivalent methods.

3.3.2.3 For close-up survey of the frame of cargo hold for bulk carriers of less than 100,000 deadweight, one or more of the following means for access, acceptable to the Surveyor, is to be provided:

- Permanent staging and passages through structure

- Temporary staging and passages through structure

-- For the lower end of framework, including the floor plate, adopt a movable ladder not more than 5 m, subject to the approval by the Surveyor

- Vehicles with hydraulic arms, including cherry picker, lift and movable platform

-- Small boat or raft, if the cargo hold structure may support the hydrostatic pressures at all water levels

- Other equivalent methods

3.3.2.4 For close-up survey of the frame of cargo hold for bulk carriers of 100,000 tonnage for the minimum, one or more of the following means for access, acceptable to the Surveyor, is to be provided, except the movable ladder (adjustable ladder):

9.4.2.4.1 Annual survey within 10 years, intermediate survey and first special survey:

- Permanent staging and passages through structure;

- Temporary staging and passages through structure;

- Vehicles with hydraulic arms, including cherry picker, lift and movable platform;

-- Small boat or raft, if the cargo hold structure may support the hydrostatic pressures at all water levels;

- Other equivalent means;

9.4.2.4.2 Follow-up intermediate survey and special survey:

-- Permanent staging or temporary staging for close-up survey and passages through structure are required to reach the upper part of framework;

-- Vehicles with hydraulic arms, such as frequently used cherry jacker, can replace the staging to reach the lower and medium parts of framework;

- Lift and movable platform;

-- Small boat or raft, if the cargo hold structure may support the hydrostatic pressures at all water levels;

-- Other equivalent methods;

Note: notwithstanding the above requirements, for annual survey of ships of 10 years of age (no more than 15 years) (the fore cargo hold) and for ships of 15 years of age or over, at least 25% of the framework will be included in the survey to decide the conditions in lower parts of the framework, including 1/3 of the lower part of side shell frames, end attachments and adjacent shell plating. It is acceptable to adopt movable ladder that locks up the upper part with mechanical device.

3.3.3 Survey equipment

3.3.3.1 During the survey, the following equipment and instructions are kept effective: explosimeter, oxygen meter, breathing apparatus, life-saving ropes, wires and safety belt and whistle for hooks. A safety inspection list is to be provided. Generally, the ultrasonic detection device is to be adopted for thickness measurement, the precision of which is to meet the requirements.

One or more of the following fracture detection procedures may be required to be conducted if deemed necessary by the Surveyor:

- Radiographic equipment;
- Ultrasonic equipment;
- Magnetic particle equipment;
- Dye penetrant.

9.4.3.3 In the survey, the following survey equipment is to be adopted if applicable;

1) During the survey, sufficient illumination is to be provided to reveal corrosion, deformation, fractures, damages or other structural deterioration. Administration-approved anti-explosion flash lamps are to be adopted in flammable atmospheric conditions. For surveys inside the tank, it is proposed to use flash lamps of strong luminous flux. Flash lamps are proposed to be fitted with bands to free the hands.

2) Hammer: except for normal applications, it is proposed to take the hammer for inner survey of units and tanks, as hammer is most usable tool to send SOS signals in case of emergency.

3) Oxygen analyzer/gasoscope: before the Surveyor enters the tank, check if the air inside is safe. It is proposed to take a handset instrument which will send alarms when the air inside is up to the unacceptable limit. The instrument is subject to the approval by the Administrations.

4) Safety belt and safety ropes: if it is possible to drop off from a height of 3m or above, safety belt and safety ropes are to be provided;

5) Ray spectrometer: to detect the ion ray generated after ray examination, it is proposed to provide ray spectrometer that will send alarms for ray detection.

6) During the survey process, provide sufficient fatigue uniform, including the helmet, gloves and safety shoes.

3.3.4 Survey at sea or at anchorage

3.3.4.1 A communication system is to be arranged between the survey party in the tank and the responsible officer on deck. When a small boat or raft is used for survey, the communication system arranged between the survey party (inside the tank) and the responsible officer on deck will cover those in control of ballast pump.

3.3.4.2 Explosimeter, oxygen-meter, breathing apparatus, lifeline and whistles are to be at hand during the survey. When boats or rafts are used, appropriate life jackets are to be available for all participants. Boats or rafts are to have satisfactory residual buoyancy and stability even if one chamber is ruptured. A safety checklist is to be provided.

3.3.4.3 Surveys of tanks by means of boats or rafts may only be undertaken at the sole discretion of the Surveyor, who is to take into account the safety arrangements provided, including weather forecasting and ship response under foreseeable conditions and provided the expected rise of water within the tank does not exceed 0.25m.

3.3.4.4 Rafts or boats alone may be allowed for inspection of the under deck areas for tanks or spaces, if the depth of the webs is 1.5 m or less.

If the depth of the webs is more than 1.5 m, rafts or boats alone may be allowed only:

(a) When the coating of the under deck structure is in GOOD condition and there is no evidence of wastage; or

(b) If a permanent means of access is provided in each bay (Bay is the area between adjacent transverse frames or transverse bulkheads) to allow safe entry and exit. This means:

i. Access direct from the deck via a vertical ladder and a small platform fitted approximately 2 m below the deck in each bay; or

ii. Access to deck from a longitudinal permanent platform having ladders to deck in each end of the tank. The platform is, for the full length of the tank, be arranged in level with, or above, the maximum water level needed for rafting of under deck structure. For this purpose, the ullage corresponding to the maximum water

level is to be assumed not more than 3 m from the deck plate measured at the midspan of deck transverses and in the middle length of the tank. (refer to Figure 3.3.4 (1))

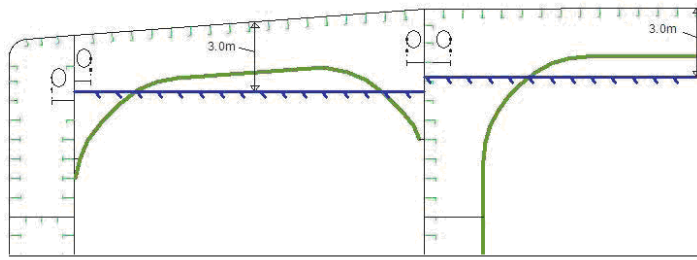


Figure 3.3.4 (1)

If neither of the above conditions are met, then staging or an “other equivalent means” is to be provided for the survey of the under deck areas.

3.3.5 Survey Programme

3.3.5.1 The owner in cooperation with CCS is to work out a specific survey programme prior to the commencement of any part of the special survey or of any part of the intermediate survey. The owner is to complete the “check list” before working out the specific survey programme. The specific survey programme is to be worked out before any of the following surveys:

- 1) Special survey;
- 2) Intermediate survey for ships of 10 years of age or over.

The programme is to be delivered in a written form. The survey programme at intermediate survey may consist of the survey programme at the previous special survey supplemented by the executive hull summary of that special survey and later relevant survey reports. It also includes the structure plan and survey equipment, and the requirements for close-up survey, thickness measurement and liquid tank testing, as well as the documents and data kept on board. The survey programme will take into account any amendments to the survey requirements implemented after the last special survey carried out.

For more details about the survey programme and check list, please refer to Appendix 11A and 11B of chapter 5, Part One in CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS.

3.3.5.2 In preparing the survey programme, the following documentation is to be collected and consulted with a view to selecting tanks, areas, and structural elements to be examined:

- 1) Survey status and basic ship information;
- 2) The documents kept on board, as stated in 3.3.5.3;

3) Main structural plans (scantlings drawings), including information regarding use of high tensile steels (HTS);

4) Relevant previous survey and inspection reports from both CCS and the owner;

5) Information regarding the use of the ship's tanks, typical cargoes and other relevant data;

6) Information regarding corrosion protection level on the new building;

7) Information regarding the relevant maintenance level during operation.

3.3.5.3 The submitted survey programme at least meets the requirements for close-up survey and thickness measurement and testing of liquid tank of bulk carriers and double-side bulk carriers given by CCS rule. The Instructions at least to include relevant information as below:

(1) Basic ship information and particulars;

(2) Main structural plans (scantlings drawings), including information regarding use of high tensile steels (HTS);

(3) Plan of tanks;

(4) List of tanks with information on use, protection and condition of coating;

(5) Conditions for survey (e.g., information regarding tank cleaning, gas freeing, ventilation, lighting, etc.);

(6) Provisions and methods for access to structures;

(7) Equipment for surveys;

(8) Nomination of tanks and areas for close-up survey;

(9) Nominations of sections for thickness measurement;

(10) Nomination of tanks for tank testing;

(11) Nomination of the agency engaged in thickness measurement;

(12) Damage experience related to the ship in question;

(13) Key structural area and suspect area;

3.3.5.4 The maximum acceptable structural corrosion diminution levels applicable to the vessel. (For more details, please refer to Appendix 1 "Criteria for Local Strength")

3.3.5.5 In preparing the survey programme, reference also may be made to Appendix 12 'Guidelines for Technical Assessment in Conjunction with Planning for Enhanced Surveys and Owner's Inspection Report' of chapter 5, Part One in CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL

SHIPS.

3.3.5.6 The survey programme is to judge the level of danger based on the acknowledged principles and practical operations.

3.3.5.7 The Surveyor will study on the structural layout, and assess the ship's operation and maintenance record. If possible, study on the information about sister ship, to check out known questionable areas, especially those related to classification. Prepare a structure draft to record any defects and ultrasonic thickness measurement results correctly.

3.3.6 Documents to be kept on board

3.3.6.1 General

1) The owner is to supply and maintain on board documentation as specified in 3.3.6.2 and 3.3.6.3, which is to be readily available for the Surveyor.

2) The documentation is to be kept on board for the lifetime of the ship.

3.3.6.2 Survey report file

1. A survey report file is to be a part of the documentation on board consisting of:

- 1) Structural survey report;
- 2) Condition Examination Report;
- 3) Thickness measurement report.

2. The survey reports are available at the ship owner and classification society's offices.

3.3.6.3 Supporting documents

The following additional documents are also to be kept onboard ships for use:

1) The survey programme as required by 3.3.5 until such time as the special survey or intermediate survey, as applicable, has been completed;

2) Main structural plans of cargo and ballast tanks (For vessels built under the IACS Common Structural Rules, these plans are to include for each structural element both the as-built and renewal thickness. Any thickness for voluntary addition is also to be clearly indicated on the plans. The midship section plan to be supplied on board the ship is to include the minimum allowable hull girder sectional properties for hold transverse section in all cargo holds);

3) Previous repair history;

4) Cargo and ballast history;

5) Inspection by ship's personnel with reference to

- Overall structural deterioration;
- Leakages in bulkheads and piping;
- Condition of coating or corrosion protection, if any;

6) Guidelines on self-check report.

7) Any other information that will help identify suspect areas and/or critical areas requiring inspection.

3.3.6.4 Prior to inspection, the Surveyor is to examine the completeness of the documentation on board, and its contents as a basis for the survey.

3.3.7 Preparation Conference

3.3.8 To ensure the safety and efficient survey, before the start of any part of the special survey or intermediate survey, a preparation conference will be held with the participation of site Surveyor, ship owner's representative, employees from thickness measurement organization (if applicable) and Captain (or the qualified representative assigned by the ship owner or ship company), to confirm the foreseeable arrangements have been properly made. Verify the following items in the conference:

- (a) Ship programme (arrival port, docking and undocking, scheduling of anchoring, and cargo ballast operation plan);
- (b) Arrangement for thickness measurement (including passages, cleaning, de-dusting, illumination, ventilation and personnel safety)
- (c) Scope of thickness measurement
- (d) Criteria for corrosion margin
- (e) After considering the coating condition and suspect area/substantial corrosion area, the scope decided for close-up survey and thickness measurement
- (f) Implementation of thickness measurement
- (g) Selection of representative points for thickness measure in ordinary areas and areas of uneven corrosion or pitting corrosion.
- (h) Define the substantial corrosion area
- (i) Contact information about the site Surveyor, thickness measurement personnel and ship owner's representatives in case of problems.

3.4 Periodical Surveys

The periodical surveys are to be carried out at regulation interval as per CCS rules. The programme of periodical surveys is of prime importance as a means for assessment of the structural condition of the hull, in particular, the structure of cargo holds and adjacent tanks. The programme consists of Special (or Renewal) Surveys carried out at five-year interval with Annual and Intermediate Surveys carried out in between Special Surveys. In addition to the periodical surveys, occasional surveys of damages and repairs are carried out. Records of typical occurrences and chosen solutions are to be available in the ship's history file.

3.4.1 Annual Surveys

3.4.1.1 Annual surveys are to be carried out on all ships within 3 months before or after each anniversary date from the date of the initial classification survey or of the completion of the last special survey. The surveys are to be carried out in accordance with the relevant requirements of Regulation 5.4.2 and 5.7.2 in chapter 5 of part 1 in CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS .

3.4.1.2 The purpose of an Annual Survey is to confirm that the general condition of the hull is maintained at a satisfactory level.

3.4.1.3 As the ship ages, cargo holds are required to be subjected to more extensive overall and close-up examinations at Annual Surveys.

3.4.1.4 In addition, overall and close-up examinations may be required for ballast tanks as a consequence of either the coating deteriorating to a *poor* condition or the structure being found to be *substantially* corroded at previous Intermediate or Special Surveys.

3.4.2 Intermediate Surveys

3.4.2.1 Intermediate surveys are to be carried out on all ships either at or between the 2nd and 3rd annual survey. Those items which are additional to the requirements of the annual surveys may be surveyed either at or between the 2nd and 3rd annual survey. The surveys are to be carried out in accordance with the relevant requirements of Regulation 5.4.3, 5.7.2&5.7.3 in chapter 5 of part 1 in CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS.

3.4.2.2 The survey also includes re-examination and thickness measurements of any suspect areas which have substantially corroded or are known to be prone to rapid wastage.

3.4.2.3 Areas in ballast tanks and cargo holds found suspect at the previous Special Survey are subject to

overall and close-up surveys, the extent of which becomes progressively more extensive commensurate with the age of the vessel.

3.4.2.4 For bulk carriers exceeding 10 years of age, the requirements of the Intermediate Survey are to be of the same extent as the previous Special Survey. However, internal examination of fuel tanks and pressure testing of all tanks are not required unless deemed necessary by the attending Surveyor.

3.4.3 Special surveys

3.4.3.1 Hull and machinery (including electrical installations) are to be subject to special surveys at 5 years intervals to renew the classification certificate. The first special survey is to be completed within 5 years from the date of the initial classification survey and thereafter 5 years from the credited date of the previous special survey. The surveys are to be carried out in accordance with the relevant requirements of Regulation 5.4.4, 5.7.2&5.7.4 of chapter 5 of part 1 in CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS.

3.4.3.2 The Special Survey concentrates on close-up examination in association with thickness determination and is aimed at detecting fractures, buckling, *substantial* corrosion and other types of structural deterioration. For details about extent of close-up examination, please refer to table 5.7.4.4. (1) ②, or 5.7.4.4. (2) ② or 5.7.4.4. (2) ③ in section 7 of part 1 in CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS.

3.4.3.3 Thickness measurements are to be carried out upon agreement with the Classification Society concerned in conjunction with the Special Survey. The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date. For details about extent of thickness measurements, please refer to table 5.7.4.5. (1) ④ or 5.7.4.5. (1) ② in section 7 of part 1 in CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS.

3.4.3.4 Deteriorated protective coating in salt water ballast spaces and structural areas showing substantial corrosion and/or considered by the surveyor to be prone to rapid wastage will be recorded for particular attention during the following survey cycle, if not repaired at the survey.

3.4.4 Periodical surveys of the outside of the ship's bottom and related items

3.4.4.1 There is to be a minimum of two examinations of the outside of the ship's bottom and related items during each five-year special survey period. One such examination is to be carried out in conjunction with the special survey. In all cases the interval between any two such examinations is not

to exceed 36 months. An extension of the docking survey of 3 months beyond the due date can be granted in exceptional circumstances. The surveys are to be carried out in accordance with relevant requirements in Section 11 of Chapter 5 of part 1 in CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS.

3.4.4.2 For bulk carriers of 15 years of age and over, inspection of the outside of the ship's bottom is to be carried out with the ship in dry dock. For bulk carriers less than 15 years of age, alternative inspections of the ship's bottom not conducted in conjunction with the Special Survey may be carried out with the ship afloat. Inspection of the ship afloat is only to be carried out when the conditions are satisfactorily and the proper equipment and suitably qualified staff are available.

3.4.5 Damage and repair surveys

3.4.5.1 Damage surveys are occasional surveys which are, in general, outside the programme of periodical hull surveys and are requested as a result of hull damage or other defects. It is the responsibility of the owner or owner's representative to inform the CCS when such damage or defect could impair the structural capability or watertight integrity of the hull. The damages are to be inspected and assessed by CCS surveyors and the relevant repairs, if needed, are to be performed. In certain cases, depending on the extent, type and location of the damage, permanent repairs may be deferred to coincide with the planned periodical survey.

3.4.5.2 Any damage in association with wastage over the allowable limits (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the surveyor, will affect the vessel's structural watertight or weathertight integrity, is to be promptly and thoroughly repaired. Areas to be considered to include: Side shell frames, their end attachments and adjacent shell plating, deck structure and deck plating, watertight bulkheads, and hatch covers and coamings.

3.4.5.3 In cases of repairs intended to be carried out by riding crew during voyage, the complete procedure of the repair, including all necessary surveys, is to be submitted to and agreed upon by CCS in advance.

3.4.5.4 Appendix 7 "GUIDELINES FOR THE SURVEY OF VOYAGE REPAIRS" in part 1 in CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS provides useful guidance for repairs to be carried out by a riding crew during a voyage.

3.4.5.5 For locations of survey where adequate repair facilities are not available, consideration may be given to allow the vessel to proceed directly to a repair facility. This may require discharging the cargo and/or temporary repairs for the intended voyage. A suitable condition of class will be imposed when temporary measures are accepted.

3.5 Structural damages and deterioration

3.5.1 General

3.5.1.1 In the context of this guidelines, structural damages and deterioration imply deficiencies caused by:

- Excessive corrosion
- Design faults
- Material defects or bad workmanship
- Navigation in extreme weather conditions
- Loading and unloading operations, water ballast exchange at sea
- Wear and tear
- Contact (with quay side, ice, touching underwater objects, etc.) but not as a direct consequence of

accidents such as collisions, groundings and fire/explosions.

Deficiencies are normally recognized as:

- Material wastage
- Fractures
- Deformations

The various types of deficiencies and where they may occur are discussed in more detail as follows:

3.5.2 Material wastage

3.5.2.1 In addition to being familiar with typical structural defects likely to be encountered during a survey, it is necessary to be aware of the various forms and possible location of corrosion that may occur to the structural members on decks, in holds, and in tanks.

3.5.2.2 General corrosion appears as a non-protective, friable rust which can occur uniformly on hold or tank internal surfaces that are uncoated. The rust scale continually breaks off, exposing fresh metal to corrosive attack. Thickness loss cannot usually be judged visually until excessive loss has occurred.

Failure to remove mill scale during construction of the ship can accelerate corrosion experienced in service. Severe general corrosion in all types of ships, usually characterized by heavy scale accumulation, can lead to extensive steel renewals. For the criteria of local strength of a ship constructed in accordance with CCS rules, please refer to appendix 1 “Criteria for Local Strength”.

3.5.2.3 Grooving corrosion is often found in or beside welds, especially in the heat affected zone. The corrosion is caused by the galvanic current generated from the difference of the metallographic structure between the heat affected zone and base metal. Coating of the welds is generally less effective compared to other areas due to roughness of the surface which exacerbates the corrosion. Grooving corrosion may lead to stress concentrations and further accelerate the corrosion process. Grooving corrosion may be found in the base material where coating has been scratched or the metal itself has been mechanically damaged. The maximum corrosion limit of the leg of fillet welding is 20%, and the edge of the butt welded seam is not to be lower than the surface of the steel plate. The welding seams exceeding the limit is to be repaired by welding, and the surface of the medals is to be derusted and cleaned before welding.

3.5.2.4 Pitting corrosion is often found in the bottom plating or in horizontal surfaces, such as face plates, in ballast tanks and is normally initiated due to local breakdown of coating. Once pitting corrosion starts, it is exacerbated by the galvanic current between the pit and other metal.

Maximum allowable pitting corrosion limit for bulk carrier are as following:

1) Maximum allowable pitting corrosion limit for non-CSR bulks carriers

A) Side structure in accordance with URS31 requirement

The pitting density of side structure is shown in Figure 3.5.(1).

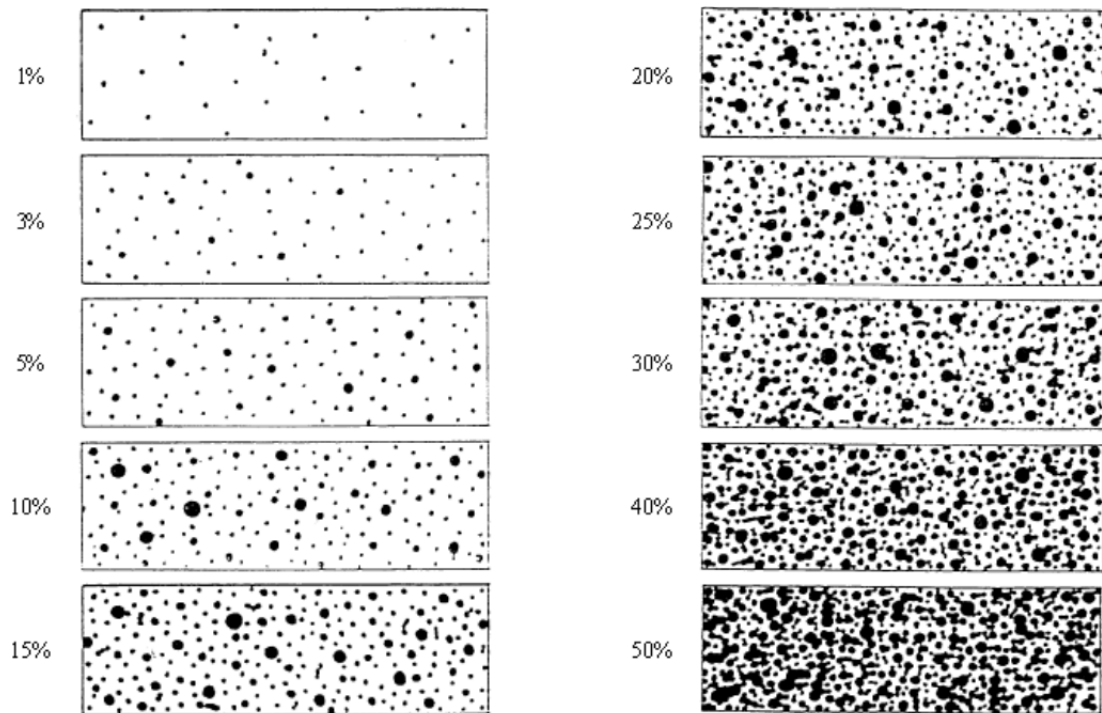


Figure 3.5 (1) Pitting Corrosion Density Figure

If pitting intensity is higher than 15% in area (A, B, C, D), thickness measurement is to be taken to check pitting corrosion. The 15% is based on pitting on only one side of a plate.

In cases where pitting is exceeding 15%, , an area of 300 mm or more, at the most pitted part of the plate (or, where this is impracticable on the frame flange or the side shell, hopper tank plating or topside tank plating attached to the side frame, an equivalent rectangular area) , is to be cleaned to bare metal and the thickness is to be measured in way of the five deepest pits within the cleaned area. The least thickness measured in way of any of these pits is to be taken as the thickness to be recorded.

The minimum remaining thickness in pits is to be greater than:

--75% of the as-built thickness, in the frame, webs and flanges of cargo holds.

--70% of the as-built thickness, in the side shell, hopper tank and topside tank plating attached to the each side frame, over a width up to 30 mm from each side of it.

If pitting intensity is lower than 15% in area, it is acceptable to have scattered pitting greater than 1/4 of the original thickness to be building up welded. If the remaining thickness is less than 6 mm, the plate is to be renewed.

B) the structures other than above A)

Other structures can refer to the corrosion criterion for side structure stated in A) above.

2) Allowable pitting corrosion limit for CSR bulks carriers

If pitting intensity in an area where coating is required by CSR is higher than 15% (pitting density shown in Figure 17.3.2), thickness measurements are to be performed to check the extent of pitting corrosion. The 15% is based on pitting on only one side of a plate.

In cases where pitting is exceeding 15%, an area of 300 mm or more, at the most pitted part of the plate, is to be cleaned to bare metal and the thickness is to be measured in way of the five deepest pits within the cleaned area. The least thickness measured in way of any of these pits is to be taken as the thickness to be recorded.

The minimum remaining thickness in pits as defined in Ch 13, Sec1, [1.2.1] of CSR is to be greater than:

-75% of the as-built thickness, in the frame and end brackets webs and flanges.

-70% of the as-built thickness, in the side shell, hopper tank and topside tank plating attached to the each side frame, over a width up to 30 mm from each side of it, without being greater than renewal.

trenewal: Renewal thickness as well as the minimum allowable thickness, mm. If the remaining thickness is lower than trenewal, structure is to be renewed.

Repair of pitting corrosion:

The following alternatives can be adopted for treatment of pitting corrosion areas: no repairs, filling with coatings or fillers, welding (building up welding for pitting corrosion) etc. Appropriate methods are to be used according to pitting corrosion intensity, corrosion depth and corrosion position with reference to foresaid corrosion limits of different types of ships.

The following survey guidelines can only be used as the guide for solving problems. Specific analysis is to be made on a case-by-case basis on site. Methods exceeding this guideline are to be under the consent of the CCS.

Filling

Pits greater than 1/4 of the original thickness can be defined as shallow pits. These pits can be filled with coatings or fillers. Prior to filling, adopted materials and crafts are to be approved by the society. Besides, appropriate dry and surface treatment measures are to be done according to manufacturer's instructions.

Pitting may accelerate corrosion process, especially at areas with coatings. In order to control pitting corrosion, it is necessary to take actions at the beginning of corrosion. Please note: coatings or fillers used for pitting can only be used as methods to deter or deplete pitting, not as repair alternatives when remaining

thickness exceeds the maximum allowable corrosion limit.

Repair welding

Pits greater than 1/4 of the original thickness and with remaining thickness less than 6.0 mm can be welded, if the thickness is below the maximum limit.

General principles for pitting corrosion welding

In highly stressed areas and main structures withstanding main strength, pitting corrosion welding is to be strictly controlled. Only under special circumstances and with careful consideration can welding be adopted, and it is to be approved by CCS headquarters.

For HTS, welding is not to be adopted generally. Only under special circumstances it can be done. Survey branches are to apply to CCS with photos and specific reports for approval.

Considering operability of on-site welding repair and welding quality etc, it is only acceptable to have individual pits or pitting in a small area to be welded. In principle it is disagreed to have large area to be welded except some special circumstances. Survey branches are to apply to CCS with photos and specific reports for approval.

For the repair welding of over-head position (such as the lower surface of the bottom plating), welder's qualification and welding procedure are to be controlled strictly.

For the repair welding, welding material and procedures must correspond to the base material.

Clean: Heavy rust to be removed.

Drying: Proper drying of pits by torch heating or equivalent.

Preheat: Required when ambient.

Welding: Low hydrogen electrode Preferable. Reverse.

NDT: Min. 10% extent, Preferably MPI so to avoid cracks in sub-surface.

Replacing plate

If the deep pitting corrosion exceeds the maximum allowable limit, or the remaining thickness is less than 6mm, instead of welding repair method, the method of replacing plate is to be used.

Steels, types and welding material are to be in compliance with the related requirements of Materials and Welding Specifications by this society. Welding material and procedures must correspond to the base material.

After the watertight repair of hull structure, tightness test is to be done afterwards. Deep pits with pitting corrosion more than maximum allowable corrosion limits as required or with remaining thickness less than 6mm, are not to be welded, but be repaired by replacing plates.

3.5.2.5 Erosion which is caused by the wearing effect of flowing liquid and abrasion which is caused by mechanical actions may also be responsible for material wastage.

3.5.3 Fractures

3.5.3.1 In most cases fractures are found at locations where stress concentration occurs. Weld defects, flaws, and where lifting fittings used during ship construction are not properly removed are often areas where fractures are found. If fractures occur under repeated stresses which are below the yielding stress, the fractures are called fatigue fractures. In addition to the cyclic stresses induced by wave forces, fatigue fractures can also result from vibration forces introduced by main engine(s) or propeller(s), especially in the afterward part of the hull.

3.5.3.2 Fractures may not be readily visible due to lack of cleanliness, difficulty of access, poor lighting or compression of the fracture surfaces at the time of inspection. It is therefore important to identify, clean, and closely inspect potential problem areas. If the initiation points of a fracture is not apparent, the structure on the other side of the plating is to be examined.

3.5.3.3 Fracture initiating at latent defects in welds more commonly appears at the beginning or end of a run of welds, or rounding corners at the end of a stiffener, or at an intersection. Special attention is to be paid to welds at toes of brackets, at cut-outs, and at intersections of welds. Fractures may also be initiated by undercutting the weld in way of stress concentrations. Although now less common, intermittent welding may cause problems because of the introduction of stress concentrations at the ends of each length of weld.

3.5.3.4 It is to be noted that fractures, particularly fatigue fractures due to repeated stresses, may lead to serious damages, e.g. a fatigue fracture in a frame may propagate into shell plating and affect the watertight integrity of the hull. In extreme weather conditions the shell fracture could extend further resulting in the loss of part of the shell plating and consequent flooding of cargo hold.

3.5.4 Deformations

3.5.4.1 Deformation of structure is caused by in-plane load, out-of-plane load or combined loads. Such deformation is often identified as local deformation (viz. Wrinkle), i.e. deformation of panel or stiffener,

or global deformation (viz. Indent), i.e. deformation of beam, frame, girder or floor, including associated plating.

3.5.4.2 If in the process of the deformation large deformation is caused due to small increase of the load, the process is called buckling.

3.5.4.3 Deformations are often caused by impact loads/contact and inadvertent overloading. Damages due to bottom slamming and wave impact forces are, in general, found in the forward part of the hull, although stern seas (pooping) have resulted in damages in way of the after part of the hull.

3.5.4.4 In the case of damages due to contact with other objects, special attention is to be drawn to the fact that although damages to the shell plating may look small from the outboard side, in many cases the internal members are heavily damaged.

3.5.4.5 Permanent buckling may arise as a result of overloading, overall reduction in thickness due to corrosion, or contact damage. Elastic buckling will not normally be directly obvious but may be detected by evidence of coating damage, stress lines or shedding of scale. Buckling damages are often found in webs of web frames or floors. In many cases, this may be attributed to corrosion of webs/floors, wide stiffener spacing or wrongly positioned lightening holes, man-holes or slots in webs/floors.

3.5.4.6 Finally, it is to be noted that inadvertent overloading may cause significant damages. In general, however, major causes of damages are associated with excessive corrosion and contact damage.

3.5.4.7 The limits of the deformation of the structural members

Definitions:

1) Wrinkle: The twisting of the steel plates between the framing, with the maximum deflection to be measured along the framing in short distance.

2) Indent: The twisting of the framing and the steel plates, with the maximum deflection to be measured in intact framings.

Wrinkle limit of the steel plates.

1) Deformation due to collision

In a ship with transverse framing, the maximum allowable deflection f_{max} of wrinkle within $0.4L$ midships for strength deck, sheer strake and bottom shell is as follows:

$$f_{max} \leq 2.6t, s/t \leq 50$$

$$f_{\max} \leq 0.06s, s/t > 50$$

The requirement of the other position of the transverse framing and the maximum allowable deflection $f_{\max}$ of wrinkle in longitudinal framing plates is as follows:

$$f_{\max} \leq 3t, s/t \leq 50$$

$$f_{\max} \leq 0.07S, s/t > 50$$

where S- frame spacing at wrinkle, in mm; t- the thickness of the shell at wrinkle, in mm.

2) Deformation due to stress

The characteristics of deformation: the deformation of the upper deck and bottom within 0.4L midships occurs all over the breadth of the ship; regular wave wrinkles occur in plates between the framing.

The limitation of the deformation: the maximum allowable deflection in transverse framing wrinkle

$$f_{\max} \leq 15\text{mm} + 1.5t$$

the maximum allowable deflection in longitudinal framing wrinkle

$$f_{\max} \leq 20\text{mm} + 2t$$

where t- the thickness of the wrinkled plating.

The disposal for deformation: make detailed records on the stress deformation; where the deformation exceeds the limits, the plating is to be replaced by a thicker one or to be strengthened.

The limitation of the indent of the plating

The maximum allowable deflection of the indented plating

$$f_{\max} < 6L + 10\text{mm}$$

where L- the space of the framing, in m

Other requirements

- 1) The shifting of the free-end of plating is not to exceed 4% of its length.
- 2) The wrinkle of keel plate, floor, web plates of the double bottom girders is not to exceed 4% of its width.
- 3) No wrinkle is allowed in brackets, the relative shifting offset between the frame and beam at ends are not to exceed the thickness of the web frame at the same position.
- 4) No obvious bending or deformation is allowed in framing.
- 5) The torsional strength is to be given close attention for ships that total breadth of deck openings exceeds 0.6 times of the width, or that the length of the hatch exceeds 0.7 times of the distance between

centerlines of the deck strips at end of the opening.

6) The transverse strength members, especially where the transverse strength members at one fourth length of the ship deformed regularly, is to be strengthened.

7) No crack is allowed in the forced members, especially at the sheer strake, deck stringer, end of the superstructure, the connection area at shipboard or hatch corner within 0.4L midships.

3.6 Structural detail failures and repairs

3.6.1 For examples of structural defects which have occurred in service, attention is drawn to Section 5 of this guidelines. It is suggested that surveyors and inspectors are to be familiar with the contents of Section 5 before undertaking a survey.

3.6.2 Any damage to or excessive wastage of the following structures that are considered affecting the ship's Classification is to be promptly and thoroughly repaired:

- (a) Side shell frames, their end attachments and adjacent shell plating
- (b) Deck structure and deck plating between hatches
- (c) Watertight bulkheads
- (d) Hatch covers and coamings

3.6.3 In general, where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Doubler plates must not be used for the compensation of wasted plate. Repair work in tanks requires careful planning in terms of accessibility.

3.6.4 If replacement of defective parts must be postponed, the following temporary measures may be acceptable at the surveyor's discretion:

- (a) The affected area may be sandblasted and painted in order to reduce corrosion rate.
- (b) Doubler may be applied over the affected area. Special consideration is to be given to areas buckled under compression.
- (c) Stronger members may support weakened stiffeners by applying temporarily connecting elements.
- (d) Cement box may be applied over the affected area.

A suitable condition of class is to be imposed when temporary measures are accepted.

3.7 Structural Features and Key Point of Examination

3.7.1 Upper deck areas

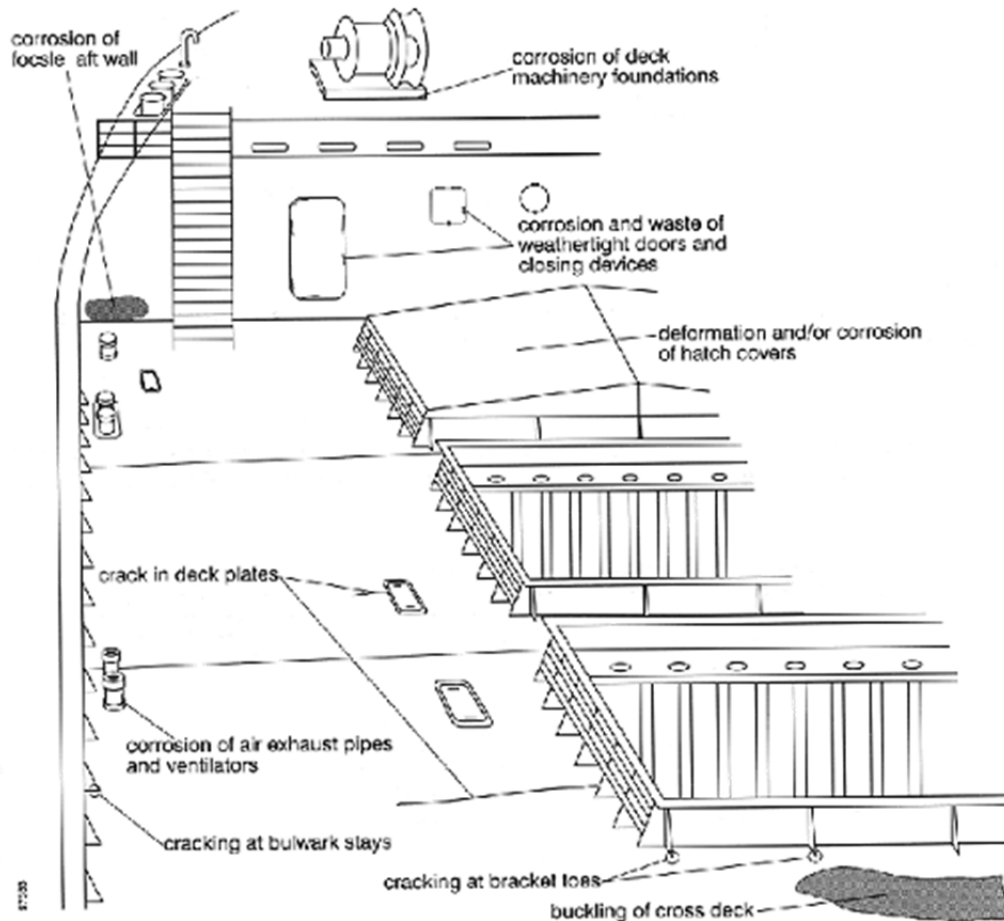


Figure 3.7.1 (1) Check points on the upper deckDeformation

3.7.1.1 The longitudinally continuous upper deck of a bulk carrier suffers hull girder stress. The longitudinal bending causes an axial force on the upper deck that may cause cracking of the deck plate at the locations where the stress is concentrated.

3.7.1.2 Bulk carriers have cargo hatchways for the convenience of cargo handling facilities. These hatchways reduce the ship's torsional strength and invite concentrated stress at the hatchway corners which may be evident by cracking of the deck plates in these areas.

3.7.1.3 Cross-deck strips come under stress by transverse bending. The transverse bulkheads provide transverse strength to a bulk carrier and the cross deck strips provide the strength to withstand the

resultant axial forces in a transverse direction.

3.7.1.4 Attention is to be paid to buckling of cross deck strips. Generally, longitudinal beams are arranged under the longitudinally continuous upper deck outboard of the side lines of the cargo hatchways. This is called the longitudinal system. When the deck beams for cross deck strips are also arranged in this manner, buckling of the cross deck strips may take place due to insufficient strength against the axial forces acting on them in a transverse direction. The transverse system is the preferred method of construction for cross deck members. Particular attention is to be given to buckling of the main deck on those ships where the cross- deck strips are arranged in the longitudinal system.

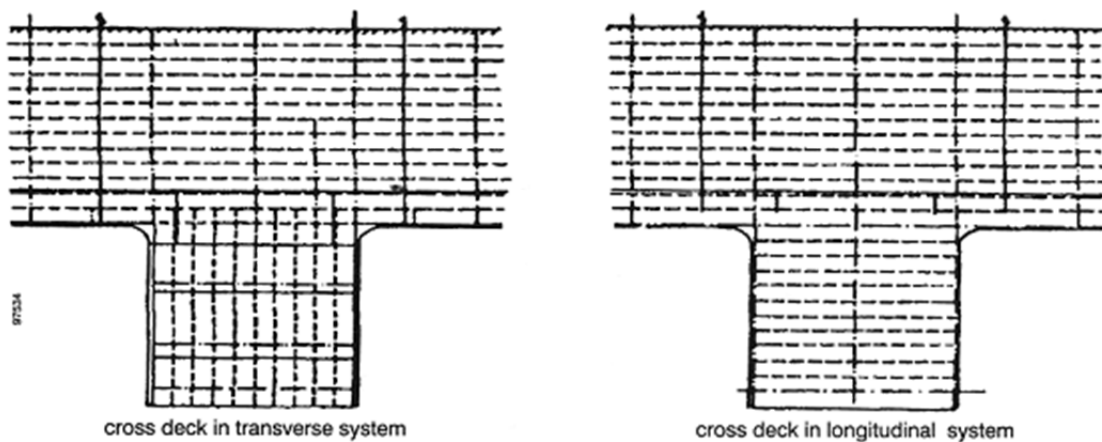


Figure 3.7.1.4 (1) : Comparison of stiffening systems for cross deck

3.7.1.5 Attention is to be paid to cracking in the upper deck. There are various types of cracking in the upper deck. Those propagating from the cargo hatchways are generally considered serious to the ship's safety:

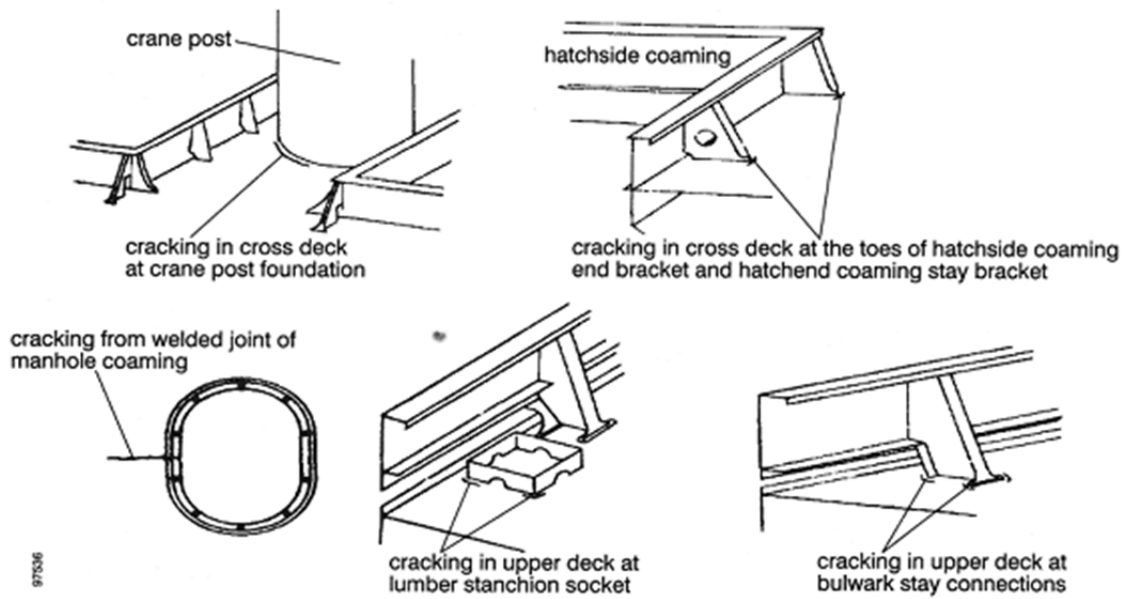


Figure 3.7.1.5(1): Various cracking in upper deck plating

- .1 Attention is to be paid whether the hatchway corners has been cracked

The large cargo hatchway openings reduce the torsional strength of the hull and invite stress concentration at their corners on the upper deck. In this regard, upper deck plating at hatchway corners is one of the focal points for cracking. Particular attention is to be paid to these areas during inspection.

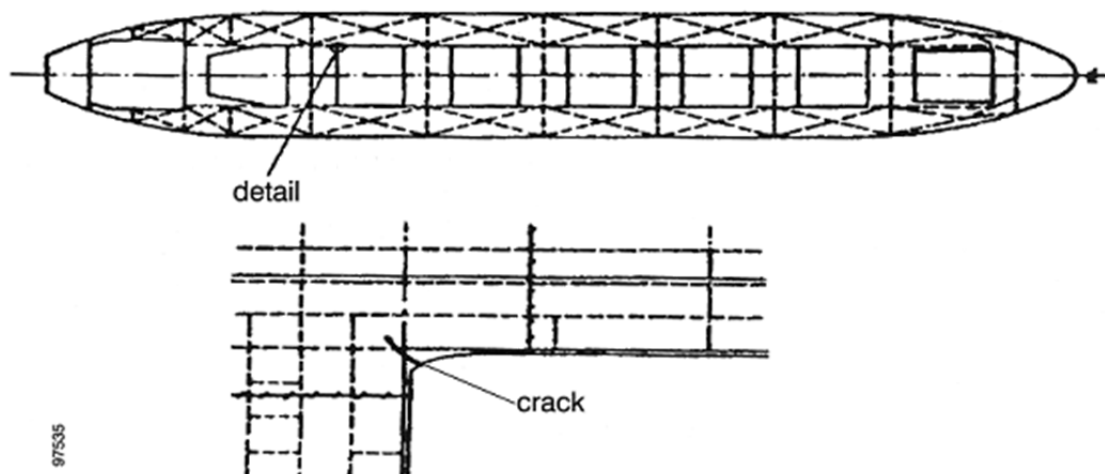


Figure 3.7.1.5 (2) : Cracking at hatchway

- .2 Attention is to be paid whether upper deck plating at deck fittings have been cracked

Various metal fittings are welded to the upper deck plating. These installations may cause stress concentrations at the welded joints or have defects in the welds. Deck platings in the vicinity of manholes, hatchside coaming end brackets, bulwark stays, crane post foundations and deck houses, etc. are to be carefully watched for cracking.

.3 Attention is to be paid whether hatch coamings plating has been cracked

Hatch coamings are subjected to hull girder stress. Although they are not critical longitudinal strength members, they are to be watched carefully to ensure that these cracks do not spread. Cracking may be initiated at defects in welded joints and metal fittings to the coamings that will invite stress concentration. Such cracking is considered serious to the ship's safety because it may be the initiation of a fracture on a large scale.

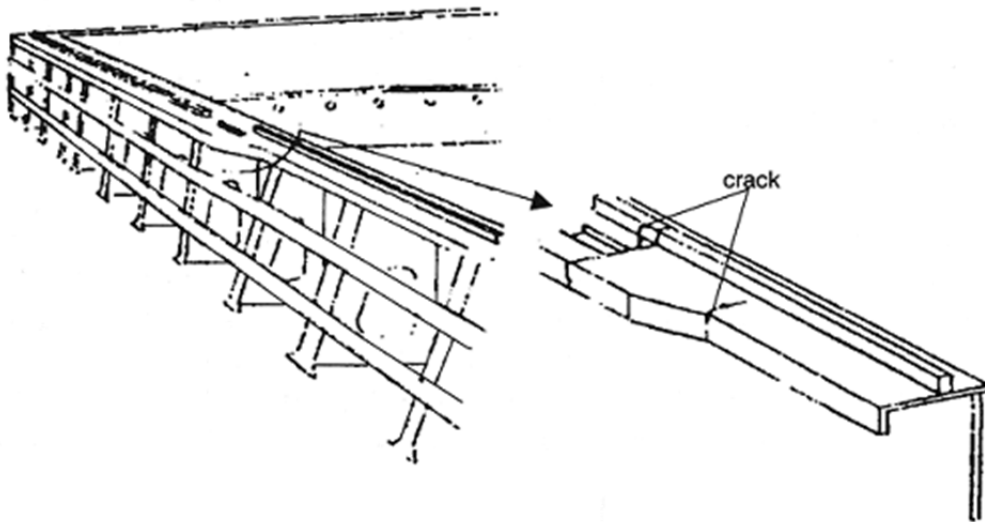


Figure 3.7.1.5 (3) : Cracking in hatch coaming

.4 Attention is to be paid whether the toe end of bracket supporting the longitudinal cargo hatch coaming has been cracked.

There is stress concentration at the toe end of bracket supporting the longitudinal hatch coaming. If the structure is designed in non-reasonable type for delivery of stress flow, the toe end is very easy to crack.



Figure 3.7.1.5 (4) Cracking in toe end of bracket

3.7.1.6 On large bulk carriers, attention is to be paid whether there is crack in corner plating of small hatch in cross deck.

3.7.1.7 Thinner steel structures on deck, such as cross-deck strips, hatch coamings, hatch covers, etc., are easily corroded and often holed. The best way to deter corrosion is to keep the structure well coated and painted. The parts most liable to corrosion in the upper deck area are as follows:

.1 Cross deck strips

The thickness of cross deck plating between hatchways is designed about a half of that of main-strength deck plating because it is not a longitudinal strength member. However, cross-deck strips provide an important part of the transverse strength of the ship, and corrosion and waste of the cross deck plating may be considered serious to the ship's soundness.

.2 Hatch covers

The thickness of hatch covers is approximately the same as that of cross decks. Holes in hatch covers caused by corrosion lead to water ingress in cargo holds, which may lead to shifting of cargo and/or problems with the stability of the ship.

.3 Hatch coamings

When steam pipes are arranged beside hatchside coamings, the corrosion progress of the coaming is very rapid. Corrosion holes of the coaming plates lead to the same problems as those associated with hatch cover

corrosion.

.4 Weathertight doors

Small hatches and wall ventilator covers Not only covers, door plates and coamings but also hinges, gaskets and clips are to be always kept in good condition.

.5 Standing pipes on deck

Vent and sounding pipes from water ballast or fuel oil tanks and ventilation pipes for closed spaces under the upper deck are liable to corrosion. If these pieces become holed, seawater comes directly into the tanks or cargo holds and may cause contamination of fuel oil, cargo damage, shifting of cargo, and/or stability problems.

.6 Forecastle aft wall

The bilges in forecastle space may cause corrosion of the bulkhead where it meets the deck. In flush decked bulk carriers, the boatswain store aft wall may be corroded in the same manner. Large bulk carriers generally do not have forecastle and have their boatswain stores down below the upper deck in fore peak spaces. Bilges left in such spaces also cause corrosion of the aft end bulkheads which separates boatswain store and No.1 cargo hold. Such wastage may lead to water ingress, cargo damage, cargo shifting, and/or stability problems.

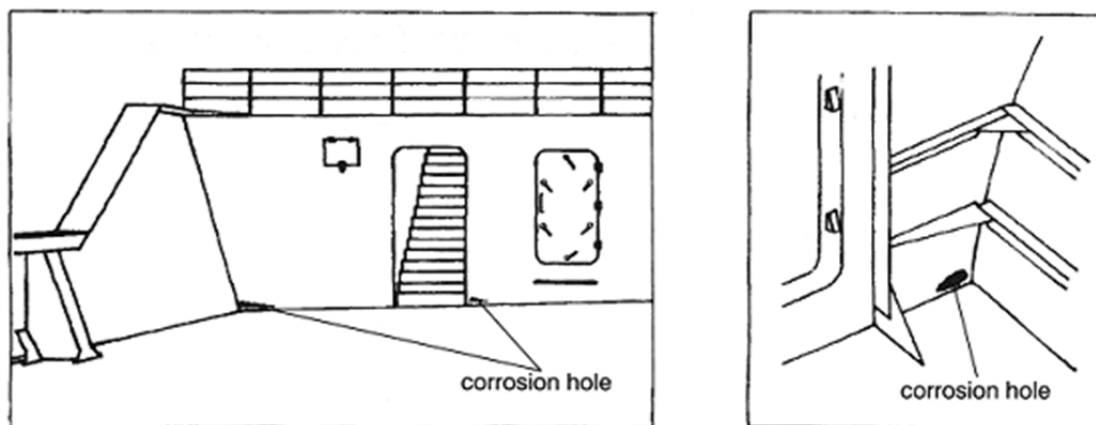


Figure 3.7.1.7 (1) : Forecastle end bulkhead

3.7.2 Cargo holds

3.7.2.1 On typical bulk carriers, the topside and bilge hopper tanks compose a double hull surrounding the cargo space, which together with the double bottom provides hull strength and rigidity. Single hulled side shells provided with individual transverse frames are located between the topside and bilge hopper tanks. In recent designs, these hold frames and end brackets are thinner than the side shell and are not constructed with web frames and side stringers as is the case with general cargo carriers.

3.7.2.2 Bulk carrier watertight transverse bulkheads at the ends of dry cargo holds are constructed in various ways, which in general can be categorized as either vertically corrugated with or without upper or lower stools, double plated with or without upper or lower stools, or plane bulkheads vertically stiffened. And the corrugated bulkhead is the most common type.

3.7.2.3 Attention is to be paid whether shell frames (including upper and lower brackets) are deformed. The shell frames are deformed due to impact by grab / forklift, or shell attached collided or high stress. Deformation due to impact by grab / forklift is generally happened in the lower part of frames and lower brackets. And the shell plating attached is easily found in sign of deformation accordingly, if the shell frames deformed are caused by shell collided. The deformation of shell frames, caused by high stress, is in sign of symmetry and regularity, which is most dangerous and high attention is to be paid by surveyor.

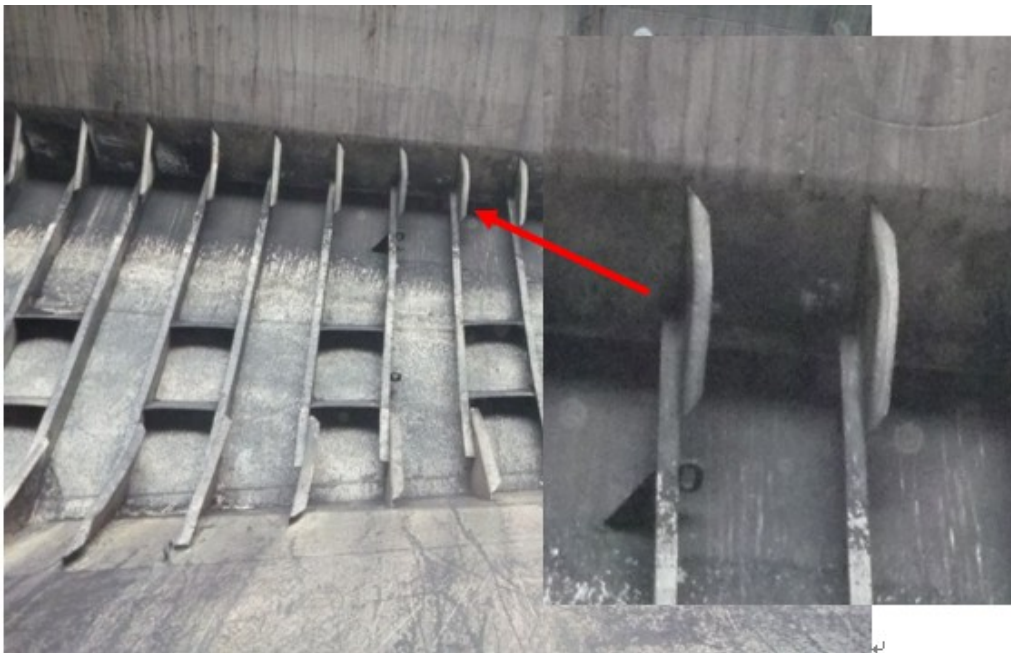


Figure 3.7.2.3 Deformation of upper brackets caused by high stress

3.7.2.4 Attention is to be paid on the transverse hatch-end beam's deformation where the beam is liable to

be defomed by the collision of wires of grab or excessive stress.

- 3.7.2.5 Attention is to be paid on the large longitudinal braket's deformation under cross deck. Due to the lack of stiffener strength of large braket, which will result in buckling and deformation, large bulk carrier is always equipped with longitudinal brackets below the cross deck.



Figure3.7.2.5 Longitudinal large bracket deformation

- 3.7.2.6 Inner bottom plate of cargo hold is liable to get collision and deformation by grab, etc.



Figure 3.7.2.6 Inner bottom deformation

3.7.2.7 Combination cargo/ballast hold In bulk carriers having combination cargo/ballast holds, cracks may often be found at or near the connection of the stool of the transverse bulkhead and the tanktop.

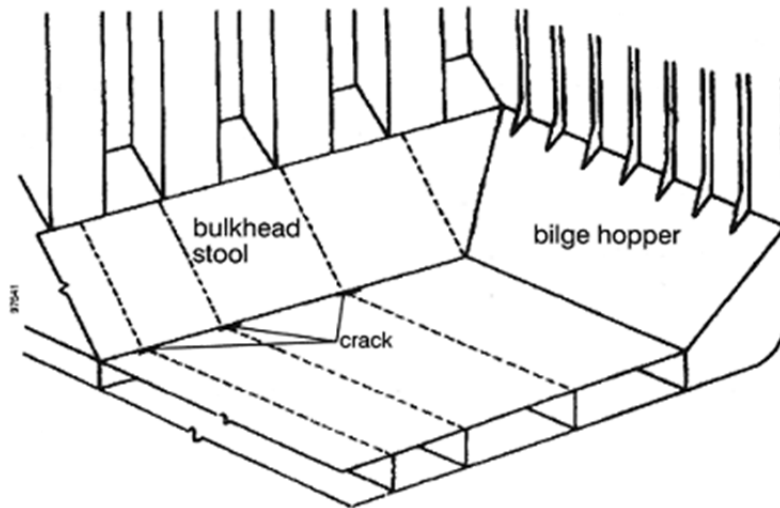


Figure 3.7.2.7 (1) Cracking at the connection of bulkhead stool and tanktop

3.7.2.8 On large bulk carriers such as capesize and panamax bulkers, bilge hopper plating around the knuckle line may be cracked along the bilge hopper transverse webs. This is considered to be caused by insufficient local reinforcement.

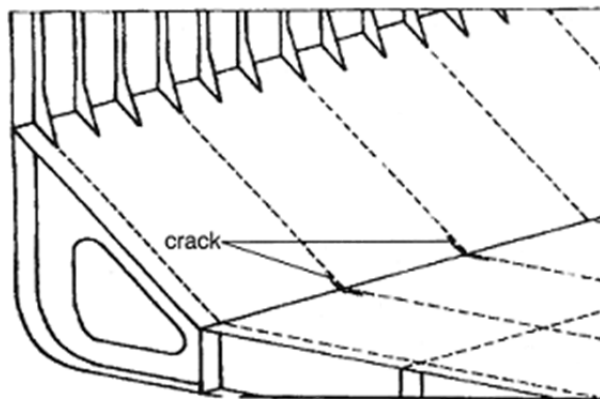


Figure 3.7.2.8 (1) Cracking in bilge hopper

3.7.2.9 Others Side stringers and/or side shells in way of No.1 cargo hold along the collision bulkhead are

often found cracked. This kind of damage is considered to be caused by insufficient continuity between fore peak construction and cargo hold structure.

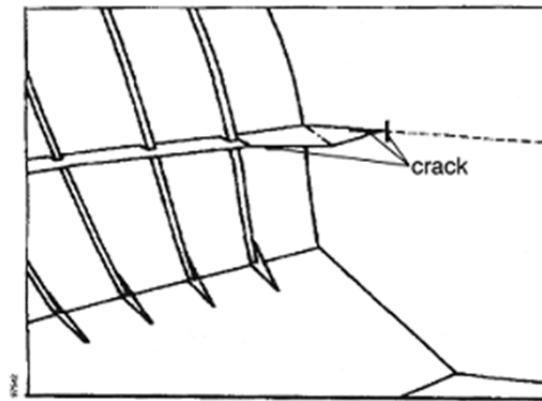


Figure 3.7.2.9 (1) Cracking around the collision bulkhead

3.7.2.10 Attention is to be paid on the transverse hatch-end beam's deformation at toe end where is liable to concentrate stress. In case of unreasonable arrangement, crack is liability, such as bracket is not extended to area of T.S.T. or the face plating of toe end is not increased.

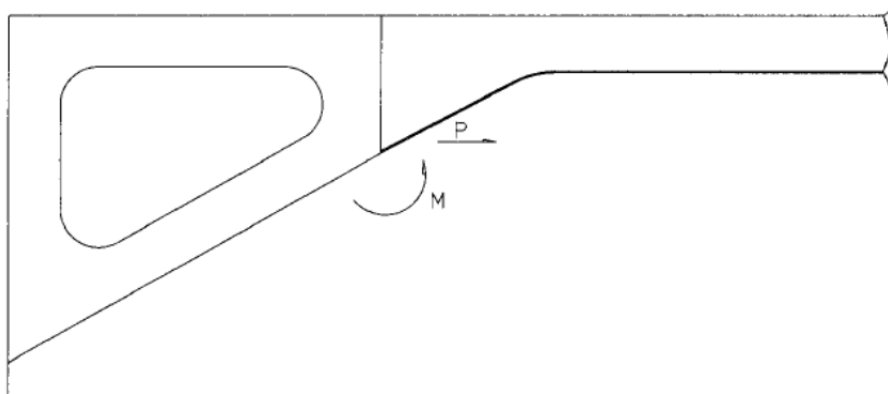


Figure 3.7.2.10 (1) Unreasonable arrangement of transverse hatch end beam



Figure 3.7.2.10 (2) Crack at beam toe end

3.7.2.11 Attention is to be paid on the large longitudinal bracket's deformation under cross deck. Primary member toe end is easily to get stress concentrated and cracks. If a crane is installed in the cross deck, the toe end of bracket supporting longitudinal girder is liable to get crack.



Figure 3.7.2.11 (1) crack at toe end of Longitudinal bracket

3.7.2.12 Attention is to be paid that the toe end of upper and lower bracket of shell frame is cracked, especially for the toe end of T-type shell frame.



Figure 3.7.2.12 (1) Crack at toe end of upper bracket

3.7.2.13 Attention is to be paid on the welding's crack between corrugated bulkhead with upper/lower stool plating, the inner bottom plating, shedder plating, gusset plating, slope plating and hopper plating and shell plating.

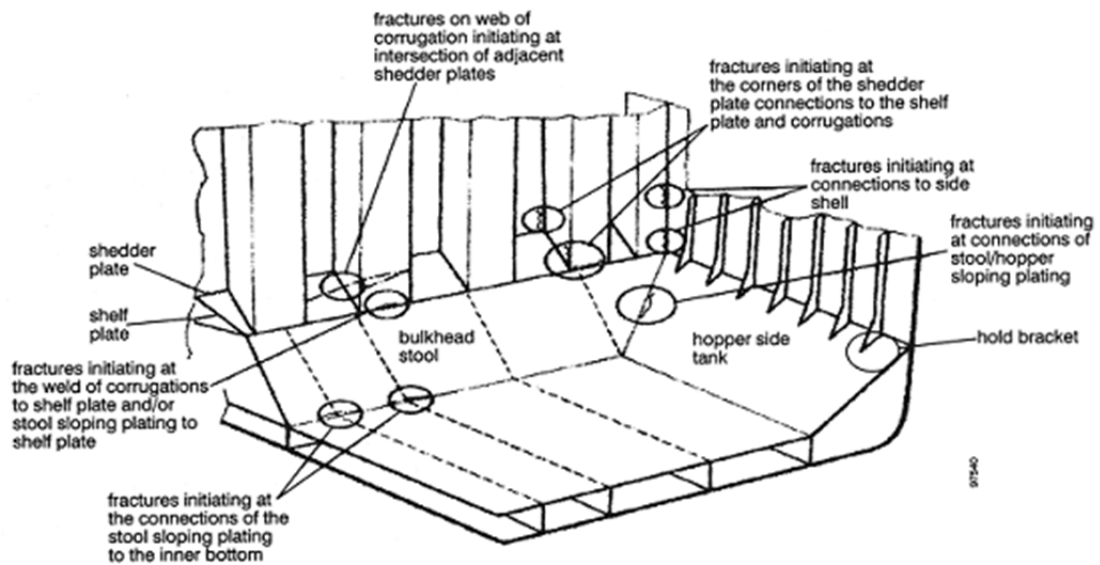


Figure 3.7.2.13 (1) Typical fracturing at the connection of transverse bulkhead structure

3.7.2.14 Attention is to be paid to the thickness reduction of shell frame in cargo hold due to corrosion, especially for the thin steel structure where the corrosion speed is growing rapidly. Among the cargo

hold components, normally the frame is the thinnest, especially in the web plate. Groove corrosion is liable appear in the fillet welding seam of frame and shell plate. Backside of frame flange plate is not easy to observe and maintain, where the corrosion is much more serious.

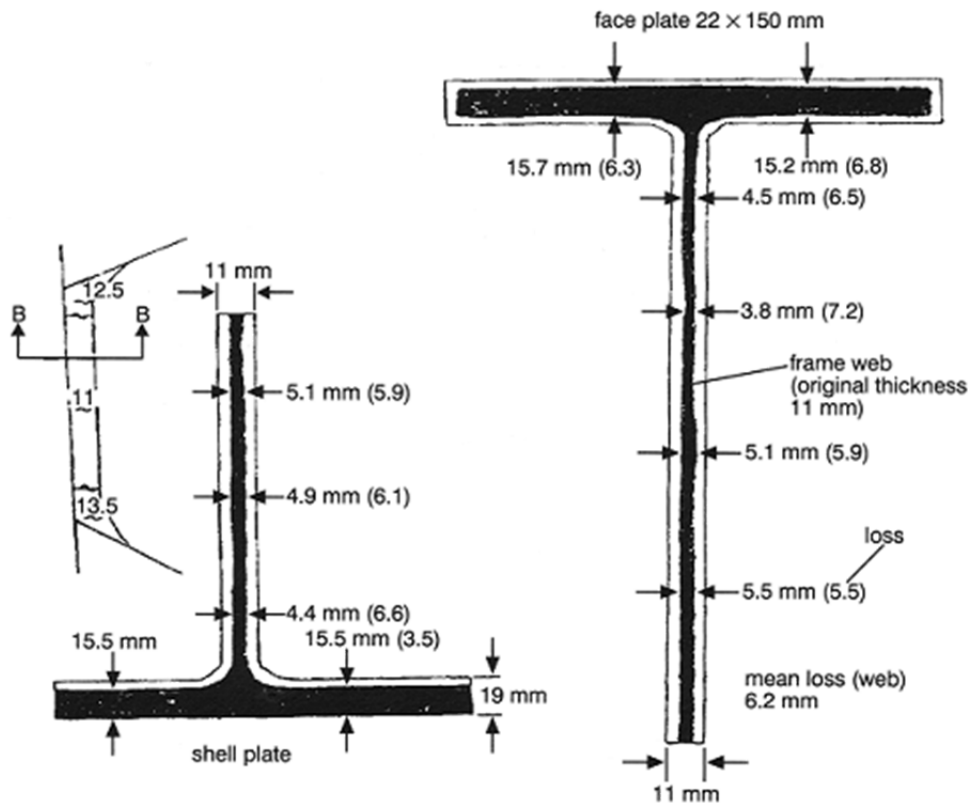


Figure 3.7.2.14 (1) : An example of a corroded hold frame

3.7.2.15 Transverse bulkheads may also be susceptible to accelerated corrosion, particularly at the mid-height and at the bottom.

3.7.2.16 Due to the lack of coating of inner bottom plate in cargo hold, as well as the abrasion of cargo, folklift and grab, the corrosion is liable to exceed standard, especially for the bulk carriers of 15 years and upwards. During the service life of bulk carrier, the inner bottom plate normally needs a replacement for all.

3.7.3 Top side tank

3.7.3.1 When inspected in T.S.T., special attentions are to be paid to side longitudinal, transverse web and bracket between shell and slop plating, which are usually collided to deform.

3.7.3.2 The transverse webs are easy to crack at the opening where longitudinals across.

3.7.3.3 The slop longitudinals in way of lower part are easy to crack at the transvers web.

3.7.3.4 Due to T.S.T is usually charge and discharge seawater, the structures in T.S.T. are susceptible to corrosion. And the upper portion is more susceptible to corrosion because the protective coating will easily deteriorate due to heat from the upper deck and the cyclic wet/dry effect of seawater. The coating is easy to break down at free edge of structure, so that the all around opening in transverse web, all around drain hole / air hole in longitudinal, face plating of transvers web & longitudinal are susceptible to corrosion.

3.7.3.5 Hopper tank / Double bottom tank

3.7.3.6 Attention is to be paid whether transverse webs in hopper tank are deformed during inspection, which is easy to deform under high stress, because hopper tank is in corner area of hull girder.

3.7.3.7 Attention is to be paid at following connections during inspection, which is easy to crack.

.1 Intersections of longitudinals and solid floors

Cracks may be found in the side, bottom and/or tanktop longitudinals at intersections with solid floors or bilge hopper transverses. Cracks also may be found in the floors or transverses occurring at the corners of the slots cut for longitudinals.

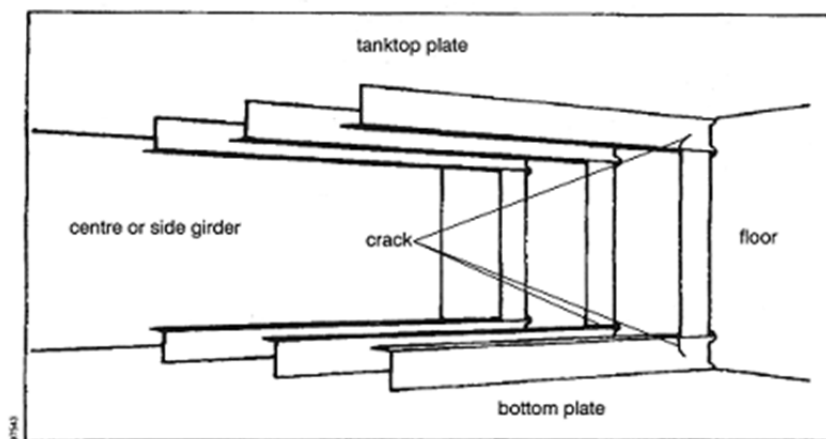


Figure 3.7.4.2 (1) Cracking in tanktop/bottom longitudinals



Figure 3.7.4.2 (2) Cracking in inner bottom Longitudinal

.2 Cracking of longitudinals at areas of structural discontinuity

Longitudinals may be cracked at the ends of additional (partial) side girders provided in the double bottom below cargo hold bulkheads or at the side walls of bilge wells for cargo holds, due to additional stress concentration caused by the structural discontinuity at those connections.

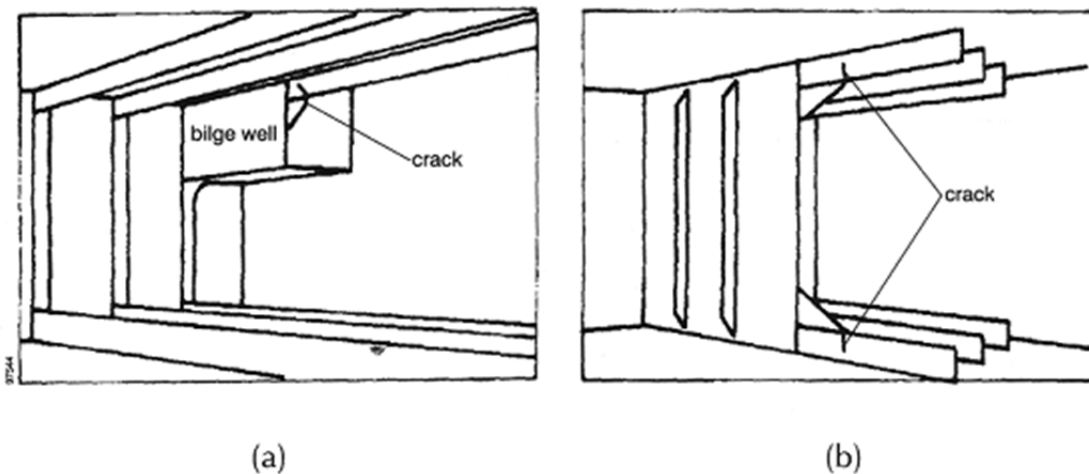


Figure 3.7.4.2 (3) Cracking at the end connection with side walls of bilge well and cracking at the end of an additional girder

.3 Bilge hopper transverse

Cracks may be observed in transverse webs in bilge hoppers initiating from the slot openings for longitudinals and at the knuckled comers of the lower ends of the hoppers.

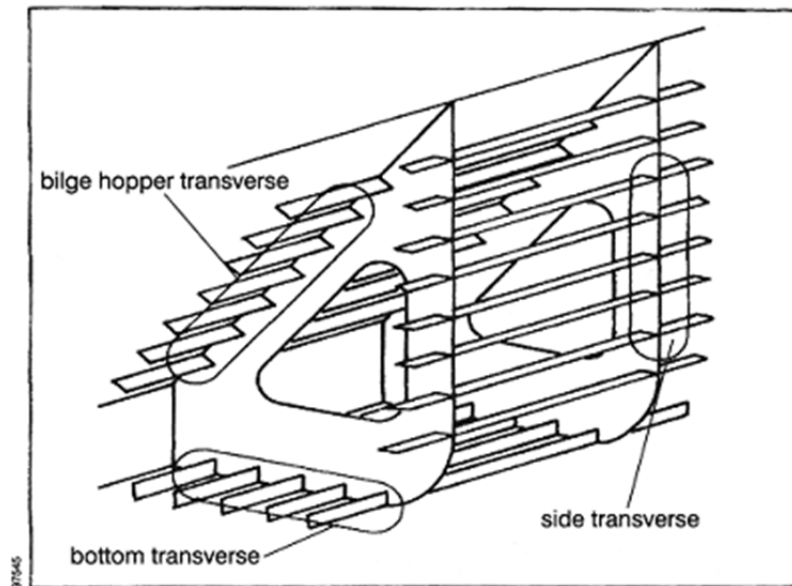


Figure 3.7.4.2 (4) Check points in bilge hopper transverse



Figure 3.7.4.2 (5) Cracking at the Opening of Trans. Web

3.7.3.8 Due to hopper tank / double bottom tank is usually in ballast condition, the coating of tank is often

in good condition and structures are less corroded. But the following area is still to be noted specially:

.1 Corrosion accelerated by heat

If there are F.O.TKS. in double bottom. The structures nearby F.O.T. are more seriously corroded.

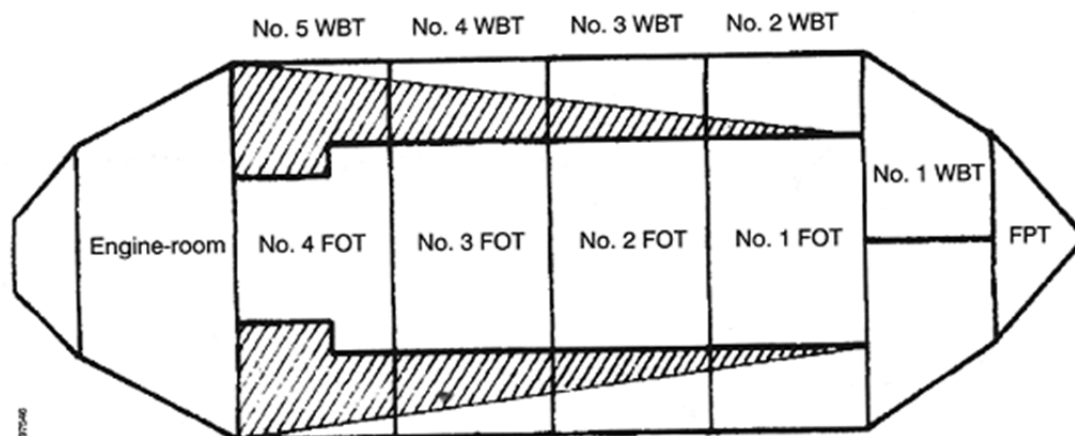


Figure 3.7.4.3 (1) : Areas where heavy corrosion due to heat effect may be found (hatched areas)

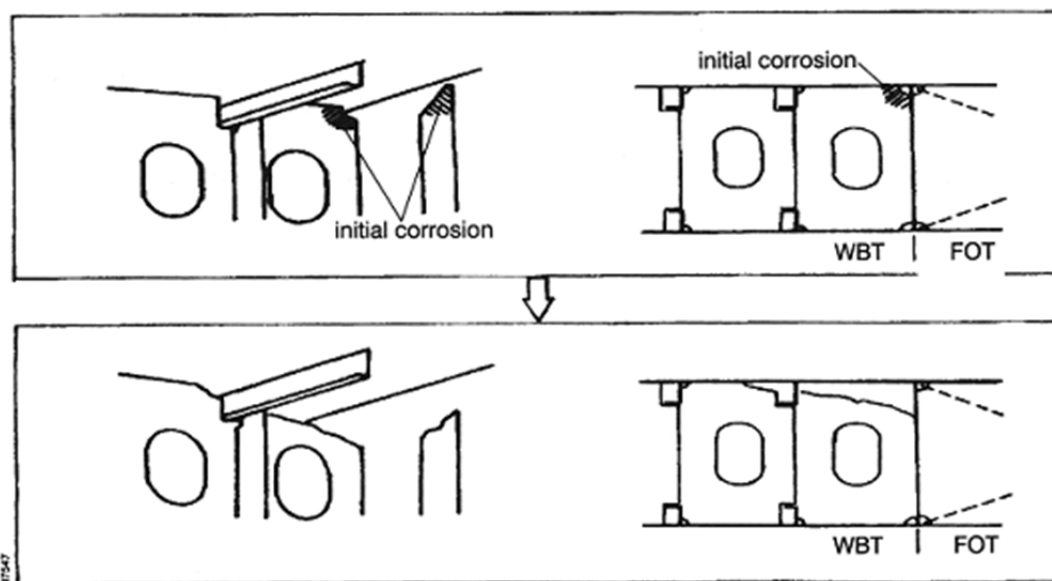


Figure 3.7.4.3 (2) : Progress of corrosion in water ballast tanks adjacent to fuel oil tanks (FOT)

.2 Areas under suction bellmouths

Bottom plates are often eroded under the suction bellmouths in tanks. On dry-docking of an older ship, the bellmouths are to be dismantled for examination of the condition of the shell plates below the bellmouths.

3.7.4 Other notices

3.7.4.1 A sounding pipe has a pad plate at its bottom end for protection of the tank bottom against the strike of the sounding scale's lead. During inspections the extent of diminution of the protection plate is to be examined. Connection trunk between topside and bilge hopper spaces

3.7.4.2 Connection trunks provided between topside and bilge hopper spaces are to be carefully watched for signs of corrosion and waste of the steelworks inside.

4. Special Requirements for Bulk Carrier

For more details about special requirements of bulk carrier, please refer to “Instruction Manual for Special Requirements of Bulk Carrier” published by CCS.

5 Structural detail failures and repairs

5.1 General

5.1.1 The **catalogue of structural detail failures and repairs** contained in this section of the **Guidelines** collates data supplied by China Classification Society and is intended to provide guidance when considering similar cases of damage and failure. The proposed repairs reflect the experience of the surveyors of this Society, but it is realized that other satisfactory alternative methods of repair may be available. However, in each case the repairs are to be completed to the satisfaction of the CCS surveyor concerned.

5.2 Catalogue of structural detail failures and repairs

5.2.1 The catalogue has been sub-divided into parts and areas to be given particular attention during the surveys:

Part 1 Cargo hold region

- Area 1 Deck structure
- Area 2 Topside tank structure
- Area 3 Side structure
- Area 4 Transverse bulkheads including stool structure
- Area 5 Double bottom including hopper tank structure

Part 2 Fore and aft end regions

- Area 1 Fore end structure
- Area 2 Aft end structure
- Area 3 Stern frame, rudder arrangement and propeller shaft support

Part 3 Machinery and accommodation spaces

- Area 1 Engine room structure
- Area 2 Accommodation structure

Part 1 Cargo hold region

Contents

Area 1	Deck structure
Area 2	Topside tank structure
Area 3	Side structure
Area 4	Transverse bulkheads including stool structure
Area 5	Double bottom including hopper tank structure

Area 1 Deck structure

Contents

1 General

2 What to look for - On-deck inspection

- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 What to look for - Under-deck inspection

- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

4 General comments on repair

- 4.1 Material wastage
- 4.2 Deformations
- 4.3 Fractures
- 4.4 Miscellaneous

Figures and/or Photographs - Area 1	
No.	Title
Photograph 1	Heavy corrosion of hatch coaming and topside tank plating vertical strake

Examples of structural detail failures and repairs - Area 1	
Example No.	Title
1	Fractures at main cargo hatch corner
2-a	Fracture of welded seam between thick plate and thin plate at cross deck
2-b	Plate buckling in thin plate near thick plate at cross deck
2-c	Overall buckling of cross deck plating
3-a	Fractures in the web or in the deck at the toes of the longitudinal hatch coaming termination bracket
3-b	Fractures in the web or in the deck at the toes of the longitudinal hatch coaming termination bracket
4	Fractures in deck plating initiated from weld of access manhole
5	Deformed and fractured deck plating around tug bitt
6	Fractures around cut-outs in cross deck girder
7-a	Buckling of hatch coaming and hatch end beam
7-b	Fractures in hatch end beam at knuckle joint

Examples of structural detail failures and repairs - Area 1	
Example No.	Title
8	Fractures in hatch end beam at the joint to topside tank
9	Fractures in hatch end beam around feeding holes
10-a	Fractures in hatch coaming top plate at the termination of rail for hatch cover
10-b	Fractures in hatch coaming top plate at the termination of rail for hatch cover
11	Fractures in hatch coaming top plate initiated from butt weld of compression bar
12	Fractures in deck plating at the pilot ladder access of bulwarks

1 General

- 1.1** Deck structure outside hatches is subjected to longitudinal hull girder bending, caused by cargo distribution and wave actions. Moreover deck structure may be subjected to severe load due to green sea on deck, excessive deck cargo or improper cargo handling. Certain areas of the deck may also be subjected to additional compressive stresses caused by slamming or bow flare effect at the fore ship in heavy weather.
- 1.2** The cross deck structure between cargo hatches is subjected to transverse compression from the sea pressure on the ship sides and in-plane bending due to torsional distortion of the hull girder under wave action. Area around the corners of a main cargo hatch can be subjected to high cyclical stress due to the combined effect of hull girder bending moments, transverse and torsional loading.
- 1.3** Discontinuous cargo hatch side coamings can be subjected to significant longitudinal bending stress. This introduces additional stresses at the mid-length of hatches and stress concentrations at the termination of the side coaming extensions.
- 1.4** Hatch cover operations, in combination with poor maintenance, can result in damage to cleats and gasket, leading to the loss of weathertight integrity of the hold spaces. Damage to hatch covers can also be sustained by mishandling and overloading of deck cargoes.
- 1.5** The marine environment, the humid atmosphere due to the water vapour from the cargo in cargo holds, and the high temperature on deck and hatch cover plating due to heating from the sun may result in accelerated corrosion of plating and stiffeners making the structure more vulnerable to the exposures described above.
- 1.6** Bulwarks are provided for the protection of crew and cargoes, and lashing of cargoes on deck. Although bulwarks are not normally considered as a structural item which contributes to the longitudinal strength of the hull girder, they can be subjected to significant longitudinal bending stress which can lead to fracture and corrosion, especially at the termination of bulwarks, such as at pilot ladder access or expansion joints. These fractures may propagate to deck plating and cause serious damage.
- 1.7** The deterioration of fittings on deck, such as ventilators, air pipes and sounding pipes, may cause serious deficiency in weathertightness/ watertightness and during fire fighting.
- 1.8** If the ship is assigned timber freeboards, fittings for stowage of timber deck cargo have to be inspected in accordance with ILLC 1966. Deterioration of the fittings may cause cargo to shift resulting in damage to the ship structure.

2 What to look for - On-deck inspection

2.1 Material wastage

- 2.1.1** The general corrosion condition of the deck structure, cargo hatch covers and coamings may be observed by visual inspection. Special attention should be paid to areas where pipes, e.g. fire main pipes, hydraulic pipes and pipes for compressed air, are fitted close to the plating, making proper maintenance of the protective coating difficult to carry out.
- 2.1.2** Grooving corrosion may occur at the transition between the thicker deck plating outside line of cargo hatches and the thinner cross deck plating, especially when the difference in plate thickness is large. The difference in plate thickness causes water to gather in this area resulting in corrosion ambience which may subsequently lead to grooving.

- 2.1.3** Pitting corrosion may occur throughout the cross deck strip plating and on hatch covers. The combination of accumulated water with scattered residue of certain cargoes may create a corrosive reaction.
- 2.1.4** Wastage/corrosion may affect the integrity of steel hatch covers and the associated moving parts, e.g. cleats, pot-lifts, roller wheels, etc. In some ships pontoon hatch covers with tarpaulins are used. The tarpaulins are liable to tear due to deck cargo, such as timbers, and cause heavy corrosion to the hatch covers.

2.2 Deformations

- 2.2.1** Plate buckling (between stiffeners) may occur in areas subjected to in-plane compressive stresses, in particular if corrosion is in evidence. Special attention should be paid to areas where the compressive stresses are perpendicular to the direction of the stiffening system. Such areas may be found in the cross deck strips between hatches when longitudinal stiffening is applied (See **Examples 2-b** and **2-c**).
- 2.2.2** Deformed structure may be observed in areas of the deck, hatch coamings and hatch covers where cargo has been handled/loaded or mechanical equipment, e.g. hatch covers, has been operated. In exposed deck area, in particular deck forward, deformation of structure may result from shipping green water.
- 2.2.3** Deformation/twisting of exposed structure above deck, such as side-coaming brackets and bulwarks, may result from impact due to improper handling of cargo and cargo handling machinery. Such damages may also be caused by shipping of green sea water on deck in heavy weather.

2.3 Fractures

- 2.3.1** Fractures in areas of structural discontinuity and stress concentration will normally be detected by close-up inspection. Special attention should be given to the structures at cargo hatches in general and to corners of deck openings in particular.
- 2.3.2** Fractures initiated in the deck plating outside the line of hatch (See **Example 1**) may propagate across the deck resulting in serious damage to hull structural integrity. Fractures initiated in the deck plating of the cross deck strip, in particular at the transition between the thicker deck plating and the thinner cross deck plating (See **Example 2-a**), may cause serious consequences if not repaired immediately.
- 2.3.3** Other fractures that may occur in the deck plating at hatches and in connected coamings can result/originate from:
- (a) The geometry of the corners of the hatch openings.
 - (b) Grooving caused by wire ropes of cargo gear.
 - (c) Welded attachment and shedder plate close to or on the free edge of the hatch corner plating.
 - (d) Fillet weld connection of the coaming to deck, particularly at a radiused coaming plate at the hatch corner plating.
 - (e) Attachments, cut-outs and notches for securing devices, and operating mechanisms for opening/closing hatch covers at the top of the coaming and/or coaming top bar, if any, at the mid-length of hatch (See **Examples 10-a, 10-b** and **11**).
 - (f) The termination of the side coaming extension brackets (See **Examples 3-a** and **b**).

- 2.3.4 Fractures in deck plating often occur at the termination of bulwarks, such as pilot ladder recess, due to stress concentration. The fractures may propagate resulting in serious casualty when the deck is subject to high longitudinal bending stress (See **Example 12**).

3 What to look for - Under-deck inspection

3.1 Material wastage

- 3.1.1 The level of wastage of under-deck stiffeners/structure in cross deck may have to be established by means of thickness measurements. The combined effect of the marine environment and the high humidity atmosphere within cargo hold s will give rise to a high corrosion rate.
- 3.1.2 Severe corrosion of the hatch coaming plating inside cargo hold and topside tank plating vertical strake may occur due to difficult access for the maintenance of the protective coating. This may lead to fractures in the structure (See **Photograph 1**).



Photograph 1 **Heavy corrosion of hatch coaming and topside tank plating vertical strake**

3.2 Deformations

- 3.2.1 Buckling should be looked for in the primary supporting structure, e.g. hatch end beams and topside tank plating vertical strake. Such buckling may be caused by:
- (a) Loading deviated from loading manual (block loading).
 - (b) Excessive sea water pressure in heavy weather.
 - (c) Excessive deck cargo.
 - (d) Sea water on deck in heavy weather.
 - (e) Combination of these causes.
- 3.2.2 Improper ventilation during ballasting/deballasting of topside tank/ballast hold may cause deformation in deck structure. If such deformation is observed, internal inspection of topside tank/ballast hold should be carried out in order to confirm the nature and the extent of damage.

3.3 Fractures

- 3.3.1 Fractures may occur at the connection between the deck plating, transverse bulkhead and

girders/stiffeners. This is often associated with a reduction in area of the connection due to corrosion.

- 3.3.2 Fractures in primary supporting structure, e.g. hatch end beams, may be found in the weld connections to the topside tank plating vertical strake and to the girders.

4 General comments on repair

4.1 Material wastage

- 4.1.1 In the case of grooving corrosion at the transition between the thicker deck plating outside line of cargo hatches and the thinner cross deck plating, consideration should be given to renewal of part of, or the entire width of, the adjacent cross deck plating.
- 4.1.2 In the case of pitting corrosion throughout the cross deck strip plating, consideration should be given to renewal of part of or the entire cross deck plating.
- 4.1.3 When heavy wastage is found on under-deck structure, the whole or part of the structure may be cropped and renewed depending on the permissible diminution levels allowed by the CCS concerned.
- 4.1.4 For wastage of cargo hatch covers a satisfactory thickness determination is to be carried out and the plating and stiffeners are to be cropped and renewed as appropriate depending on the extent of the wastage.

4.2 Deformations

- 4.2.1 When buckling of the deck plating has occurred, appropriate reinforcement is necessary in addition to cropping and renewal regardless of the corrosion condition of the plating.
- 4.2.2 Where buckling of hatch end beams has occurred due to inadequate transverse strength, the plating should be cropped and renewed with additional panel stiffeners fitted.
- 4.2.3 Buckled cross deck structure, due to loss in strength caused by wastage, is to be cropped and renewed as necessary. If the cross deck is stiffened longitudinally and the buckling results from inadequate transverse strength, additional transverse stiffeners should be fitted (See **Example 2-b** and **2-c**).
- 4.2.4 Deformations of cargo hatch covers should be cropped and part renewed, or renewed in full, depending on the extent of the damage.

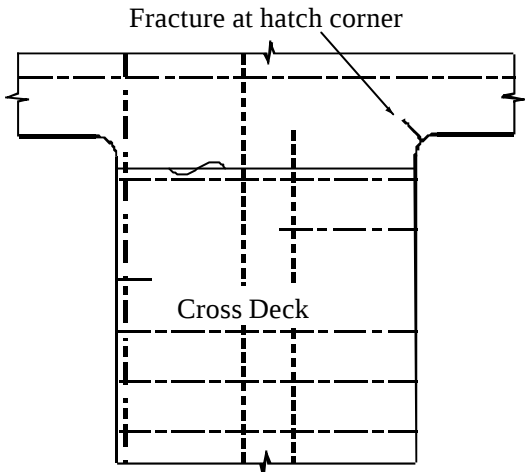
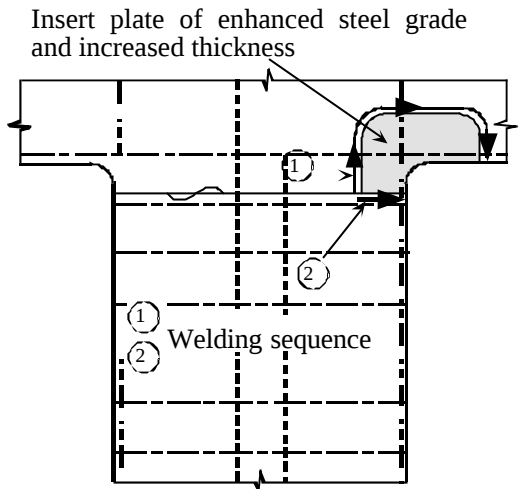
4.3 Fractures

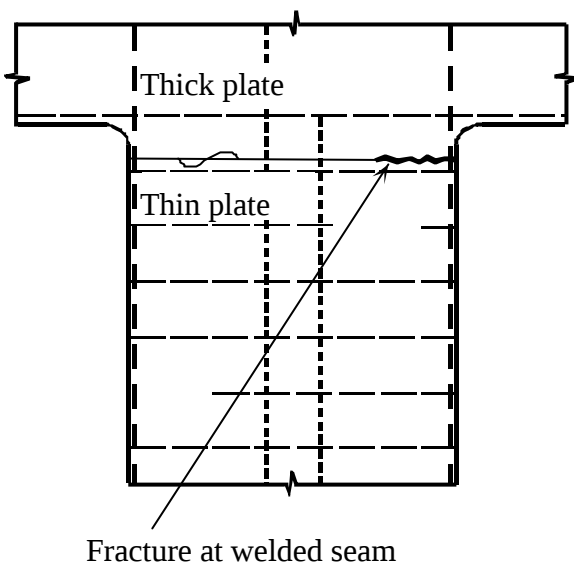
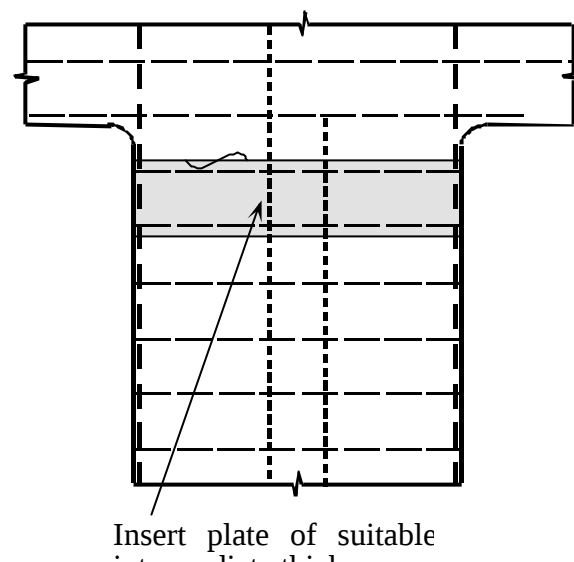
- 4.3.1 Fractures in way of cargo hatch corners should be carefully examined in conjunction with the design details (See **Example 1**). Re-welding of such fractures is normally not considered to be a permanent solution. Where the difference in thickness between an insert plate and the adjacent deck plating is greater than 3 mm, the edge of the insert plate should be suitably beveled. In order to reduce the residual stress arising from this repair situation, the welding sequence and procedure is to be carefully monitored and low hydrogen electrodes should be used for welding the insert plate to the adjoining structure.
- 4.3.2 Where welded shedder plates are fitted into the corners of the hatch coamings and the stress concentration at the deck connection is considered to be the cause of the fractures, the deck connection should be left unwelded

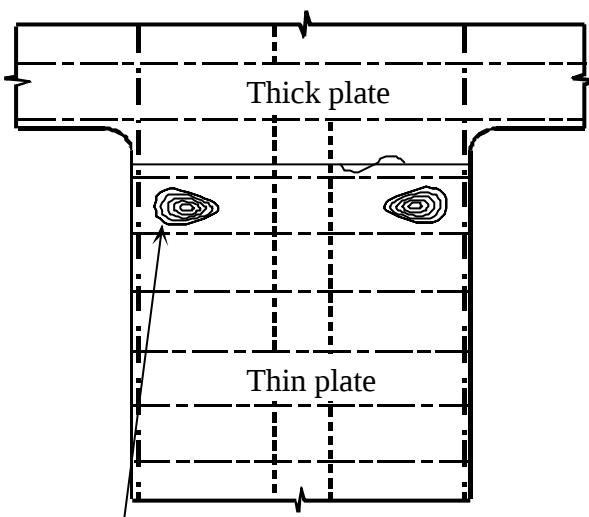
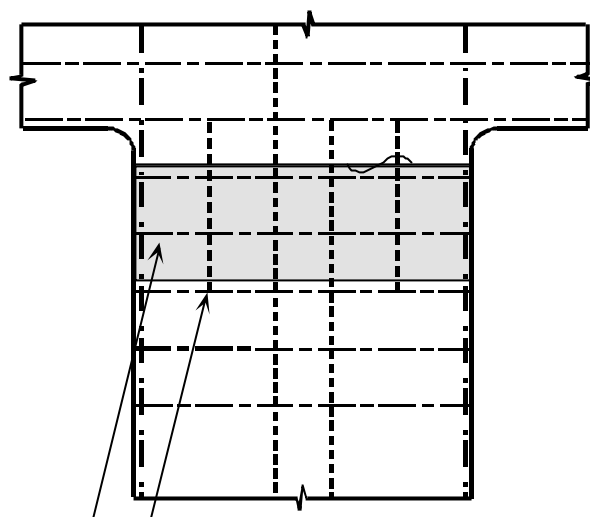
- 4.3.3** In the case of fractures at the transition between the thicker deck plating outside line of cargo hatches and the thinner cross deck plating, consideration should be given to renewal of part or the entire width of the adjacent cross deck plating, possibly with increased thickness (See **Example 2-a**).
- 4.3.4** When fractures have occurred in the connection of transverse bulkhead to the cross deck structure, consideration should be given to renew and re-weld the connecting structure beyond the damaged area with the aim of increasing the area of the connection.
- 4.3.5** Fractures of hatch end beams should be repaired by renewing the damaged structure, and by full penetration welding to the deck.
- 4.3.6** To reduce the possibility of future fractures in cargo hatch coamings the following details should be observed:
- (a) Cut-outs and other discontinuities at top of coaming and/ or coaming top bar should have rounded corners (preferably elliptical or circular in shape) (See **Example 10-b**). Any local reinforcement should be given a tapered transition in the longitudinal direction and the rate of taper should not exceed 1 in 3 (See **Example 10-a**).
 - (b) Fractures, which occur in the fillet weld connection to the deck of radiused coaming plates at the corners, should be repaired by replacing existing fillet welds with full penetration welding using low hydrogen electrodes or equivalent. If the fractures are extensive and recurring, the coamings should be redesigned to form square corners with the side coaming extending in the form of tapered brackets. Continuation brackets are to be arranged transversely in line with the hatch end coamings and the under-deck transverse.
 - (c) Cut-outs and drain holes are to be avoided in the hatch side coaming extension brackets. For fractured brackets, see **Examples 3 a and b**.
- 4.3.7** For cargo hatch covers, fractures of a minor nature may be veed-out and welded. For more extensive fractures, the structure should be cropped and part renewed.
- 4.3.8** For fractures without significant corrosion at the end of bulwarks, an attempt should be made to modify the design in order to reduce the stress concentration in connection with general cropping and renewal (See **Example 12**).

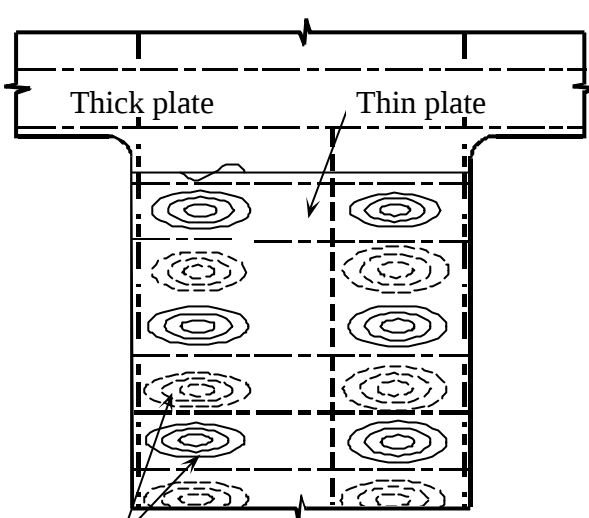
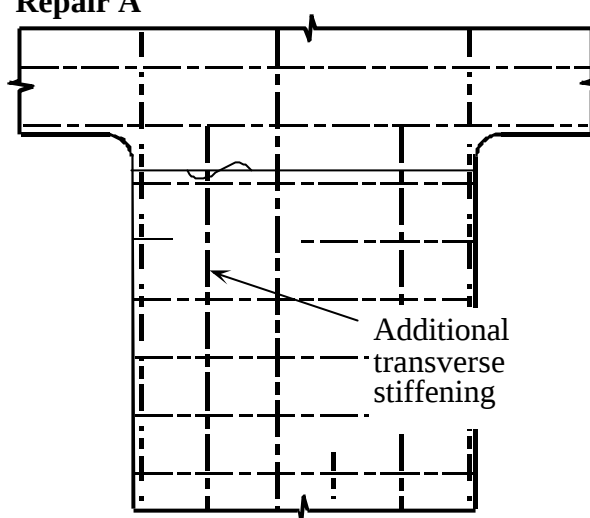
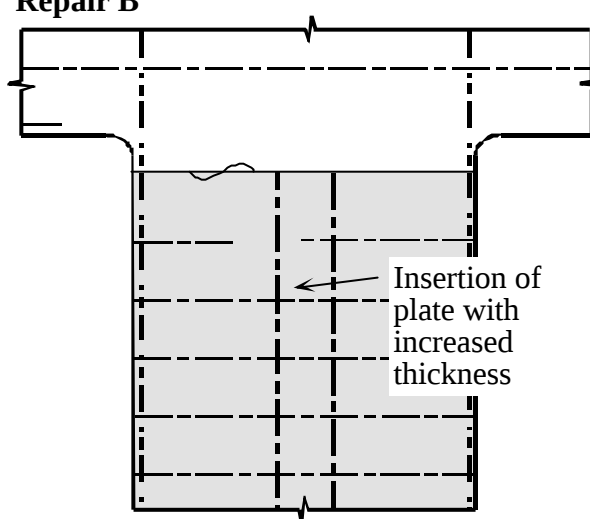
4.4 Miscellaneous

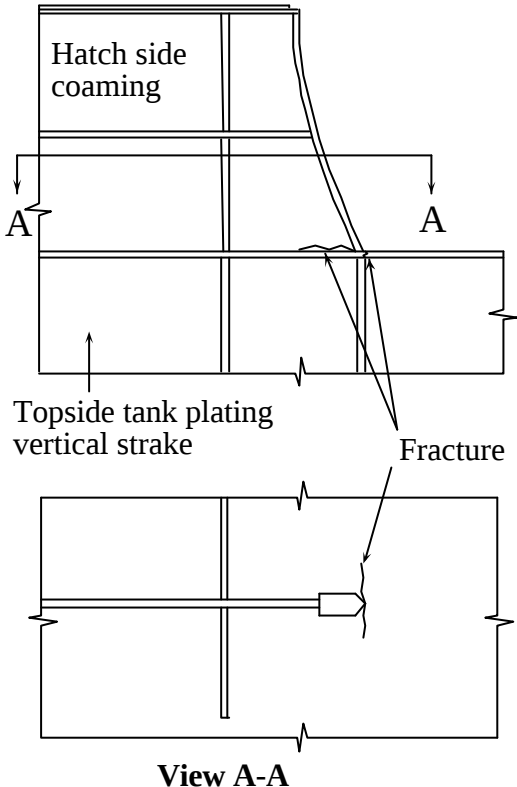
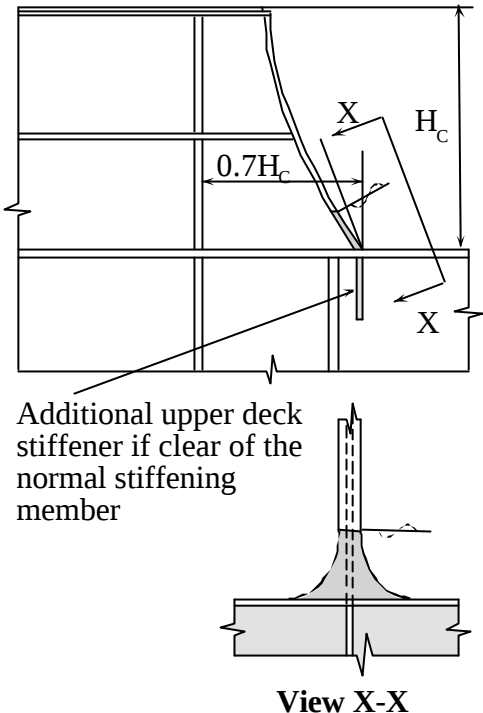
- 4.4.1** Ancillary equipment such as cleats, rollers etc. on cargo hatch covers is to be renewed as necessary when damaged or corroded.

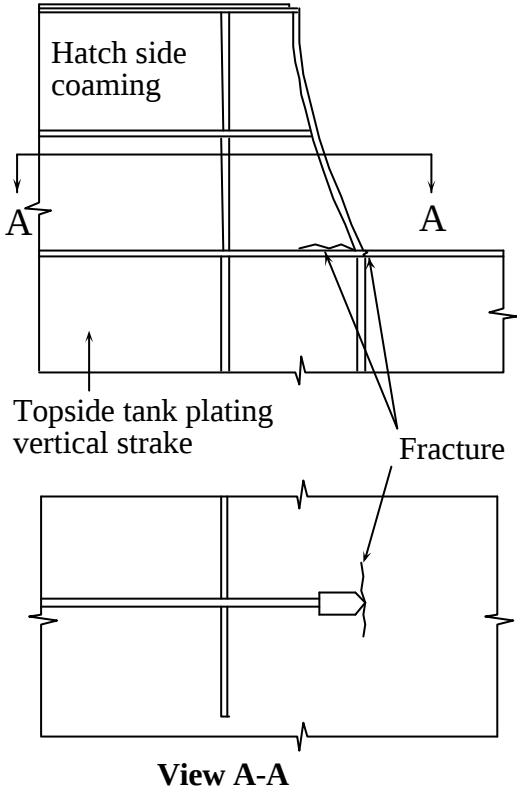
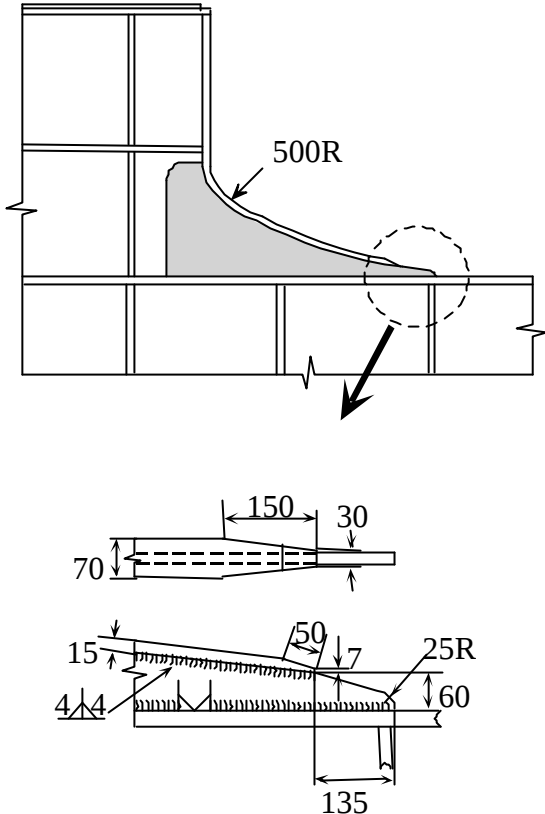
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		1
Detail of damage		Fractures at main cargo hatch corner	
Sketch of damage 		Sketch of repair Insert plate of enhanced steel grade and increased thickness 	
Notes on possible cause of damage 1. Stress concentration at hatch corners, i.e. radius of corner. 2. Welded attachment of shedder plate close to edge of hatch corner. 3. Wire rope groove.		Notes on repairs 1. The corner plating in way of the fracture is to be cropped and renewed. If stress concentration is primary cause, insert plate should be increased thickness, enhanced steel grade and/or improved geometry. Insert plate should be continued beyond the longitudinal and transverse extent of the hatch corner radius ellipse or parabola, and the butt welds to the adjacent deck plating should be located well clear of the butts in the hatch coaming. It is recommended that the edges of the insert plate and the butt welds connecting the insert plates to the surrounding deck plating be made smooth by grinding. In this respect caution should be taken to ensure that the micro grooves of the grinding are parallel to the plate edge. 2. If the cause of fracture is welded attachment of shedder plate, the deck connection should be left unwelded. 3. If the cause of the fracture is wire rope groove, replacement to the original design can be accepted.	

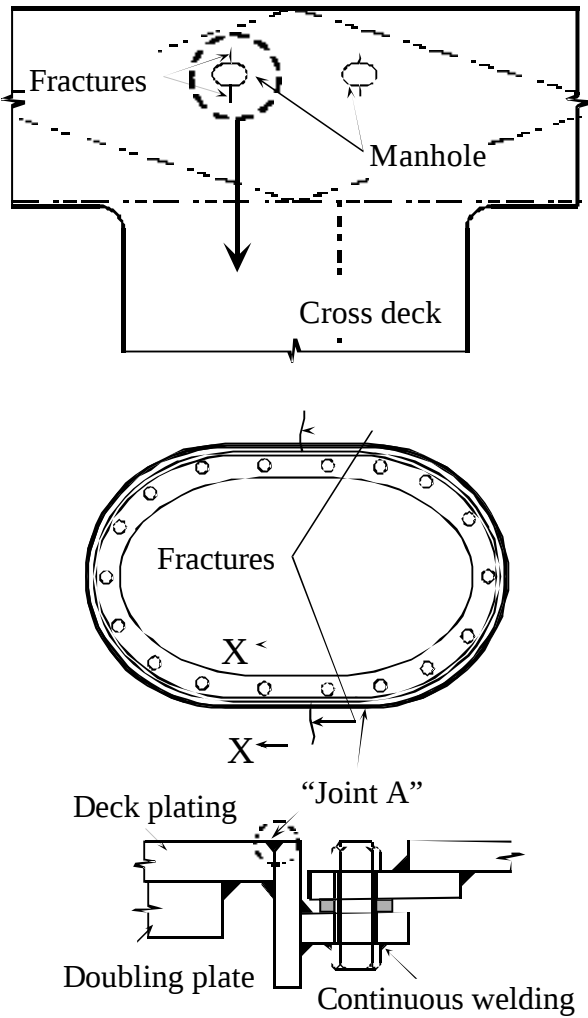
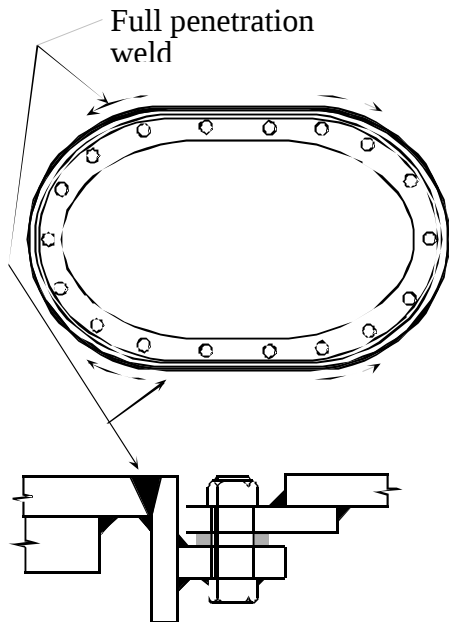
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 1	Deck structure	2-a	
Detail of damage		Fractures of welded seam between thick plate and thin plate at cross deck	
Sketch of damage		Sketch of repair	
 Thick plate Thin plate Fracture at welded seam		 Insert plate of suitable intermediate thickness	
Notes on possible cause of damage		Notes on repairs	
1. Stress concentration created by abrupt change in deck plating thickness. 2. In-plane bending in cross deck strip due to torsional (longitudinal) movements of ship sides. 3. Welded seam not clear of tangent point of hatch corner.		1. Insert plate of intermediate thickness is recommended. 2. Smooth transition between plates (beveling) should be considered.	

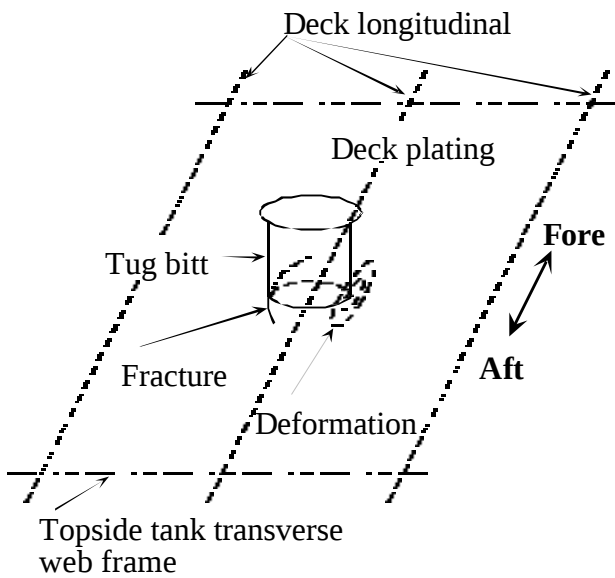
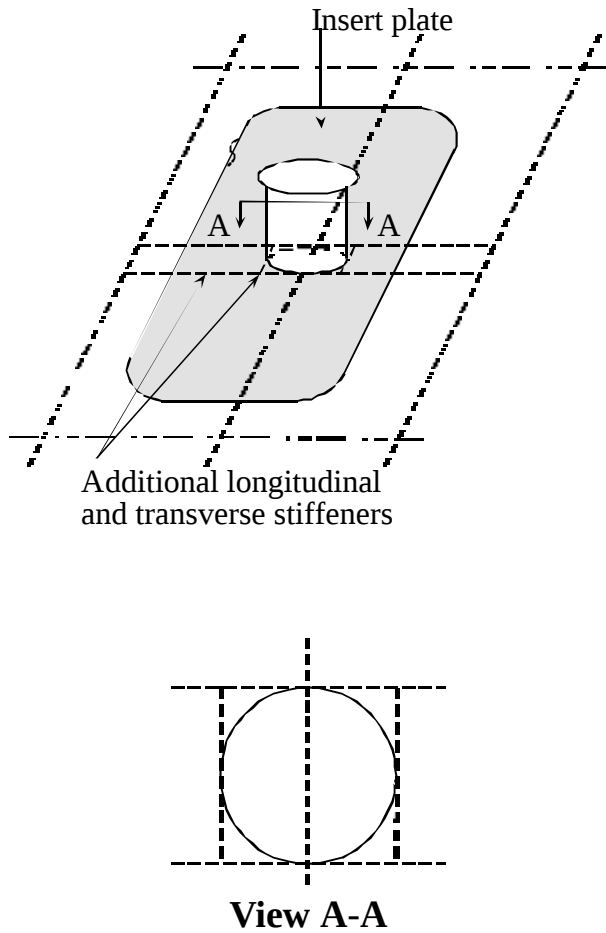
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		2-b
Detail of damage		Plate buckling in thin plate near thick plate at cross deck	
Sketch of damage		Sketch of repair	
 Buckling of cross deck plating (Buckling of hatch end structure should be examined. Refer to Example 7-a.)		 Additional transverse stiffening and/or insertion of plate with suitable intermediate thickness	
Notes on possible cause of damage 1. In-plane bending of cross deck strip due to torsional (longitudinal) movement of ship sides, often in combination with corrosion. 2. Insufficient plate thickness and/or transverse stiffening.		Notes on repairs 1. Transverse stiffeners extending from hatch sides towards centerline at least 10% of breadth of hatch, and/or increased plate thickness in the same area.	

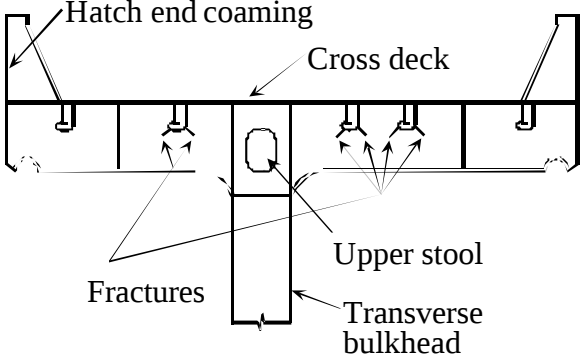
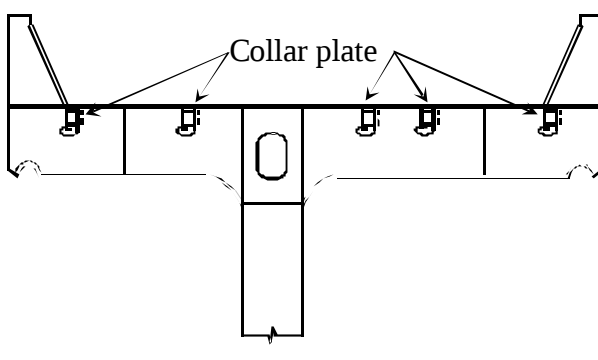
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		2-c
Detail of damage		Overall buckling of cross deck plating	
Sketch of damage		Sketch of repair	
 Buckling of cross deck plating (Buckling of hatch end structure should be examined. Refer to Example 7-a.)		Repair A  Additional transverse stiffening Repair B  Insertion of plate with increased thickness	
Notes on possible cause of damage 1. Transverse compression of deck due to sea load. 2. Transverse compression of deck due to excessive loading in two adjacent holds. 3. Insufficient plate thickness and/or transverse stiffening.		Notes on repairs 1. Repair A Plating of original thickness in combination with additional transverse stiffening. 2. Repair B Insertion of plating of increased thickness.	

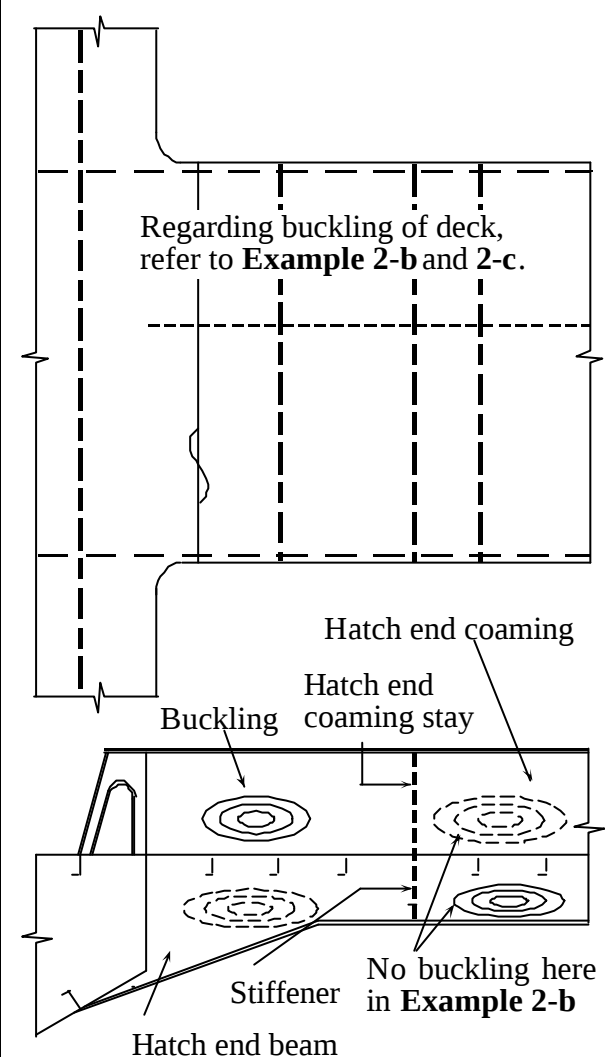
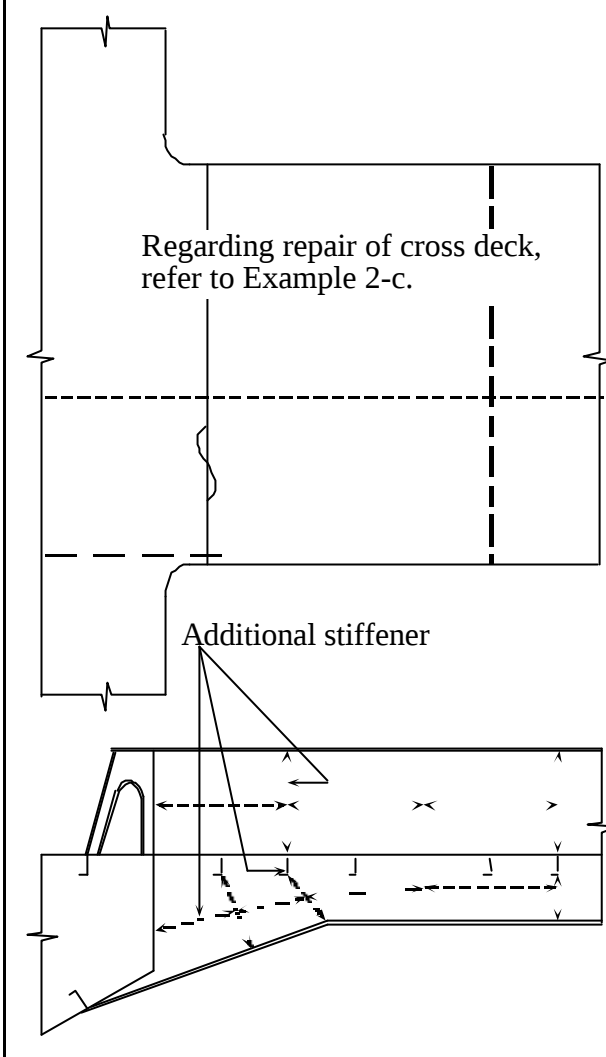
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		3-a
Detail of damage		Fractures in the web or in the deck at the toes of the longitudinal hatch coaming termination bracket	
Sketch of damage  Hatch side coaming Topside tank plating vertical strake Fracture View A-A		Sketch of repair  Additional upper deck stiffener if clear of the normal stiffening member View X-X	
Notes on possible cause of damage 1. This damage is caused by stress concentrations attributed to the design of the bracket.		Notes on repairs 1. The design of the bracket can be altered as shown above, however, it is to be ensured that an additional under deck stiffener is provided at the toe of the termination bracket, where the toe is clear of the normal stiffening member. 2. Full penetration weld for a distance of $0.15 H_c$ from toe of side coaming termination bracket and for connection of athwartship gusset bracket to deck. 3. The fracture in deck plating to be veed-out and rewelded or deck plating cropped and part renewed as appropriate, using low hydrogen electrodes for welding.	

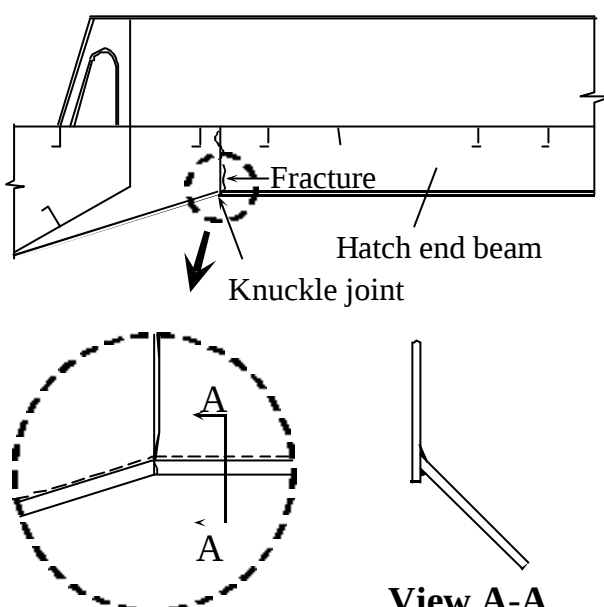
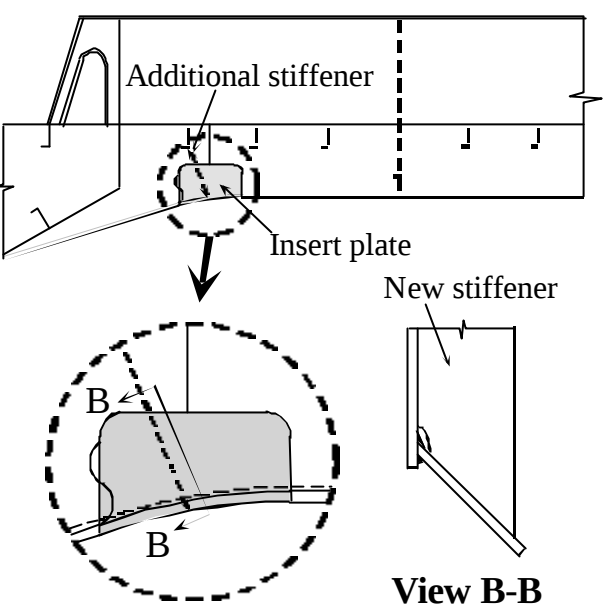
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		3-b
Detail of damage		Fractures in the web or in the deck at the toes of the longitudinal hatch coaming termination bracket	
Sketch of damage  Hatch side coaming Topside tank plating vertical strake Fracture View A-A		Sketch of repair  500R 150 30 70 15 4 4 135 60 7 25R	
Notes on possible cause of damage 1. This damage is caused by stress concentrations attributed to the design of the bracket.		Notes on repairs 1. The design of the bracket can be altered as shown above, however, it is to be ensured that an additional under deck stiffener is provided at the toe of the termination bracket, where the toe is clear of the normal stiffening member. 2. The fracture in deck plating to be veed-out and rewelded or deck plating cropped and part renewed as appropriate, using low hydrogen electrodes for welding.	

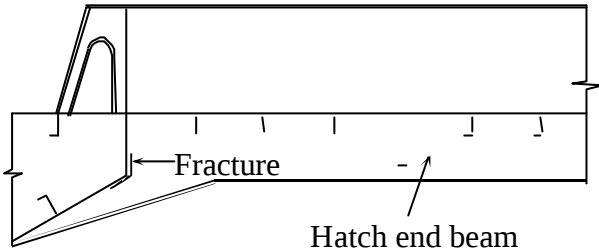
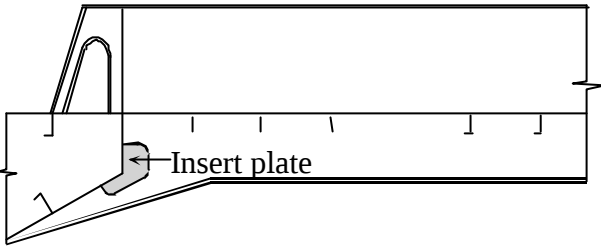
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		4
Detail of damage		Fractures in deck plating initiated from weld of access manhole	
Sketch of damage  Section X-X		Sketch of repair 	
Notes on possible cause of damage 1. Heavy weather. 2. Improper welding of joint "A".		Notes on repairs 1. The fracture in deck plating to be veed-out and rewelded, or deck plating cropped and part renewed if considered necessary. 2. Full penetration of joint "A" should be considered.	

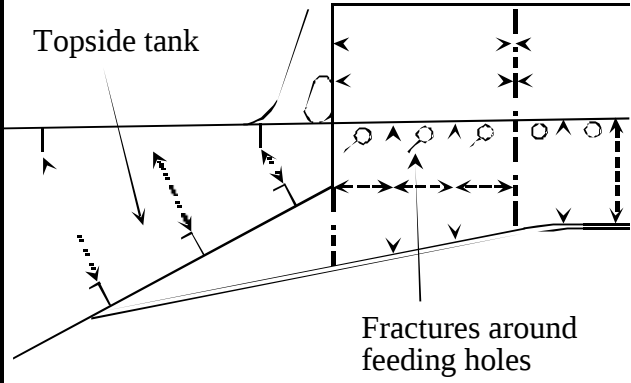
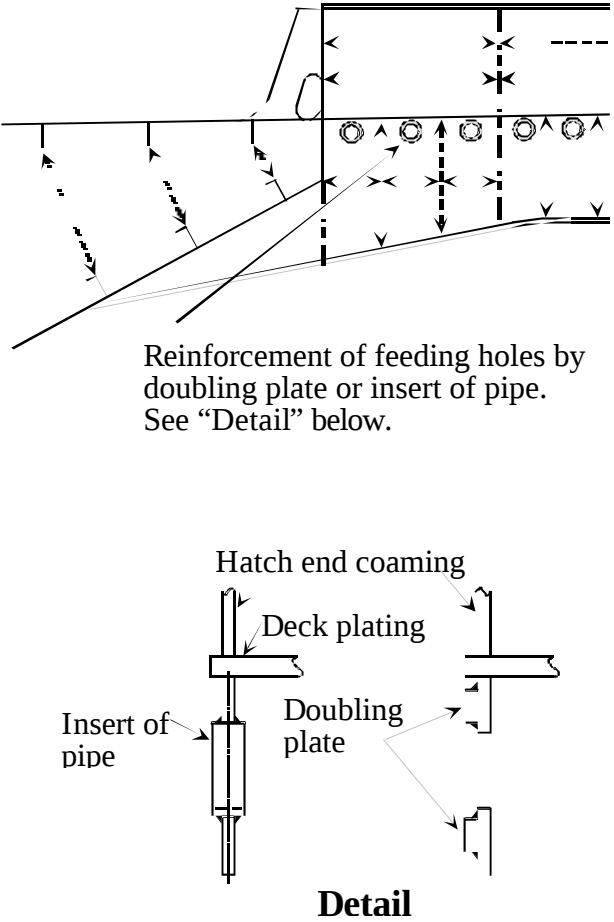
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		5
Detail of damage		Deformed and fractured deck plating around tug bitt	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage 1. Insufficient strength		Notes on repairs 1. Fractured/deformed deck plating should be cropped and part renewed. 2. Reinforcement by stiffeners should be considered.	

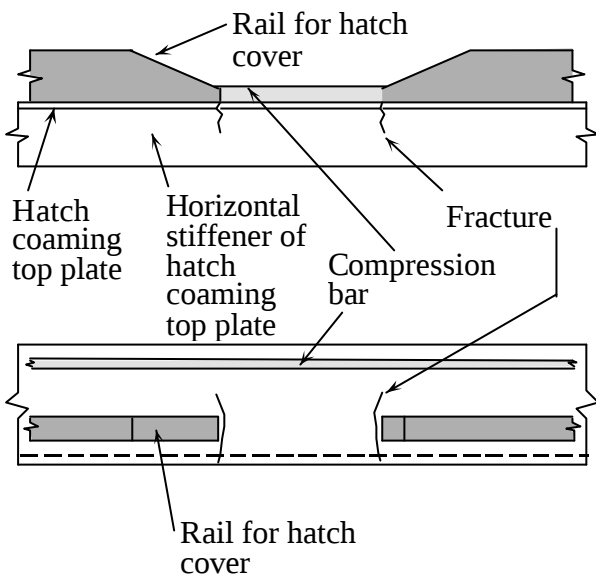
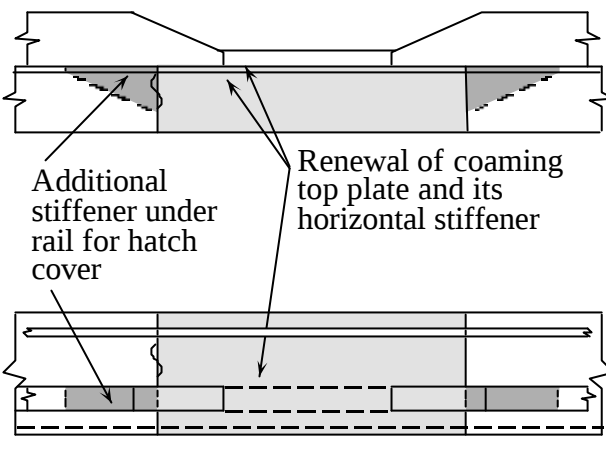
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		6
Detail of damage		Fractures around cut-outs in cross deck girder	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Stress concentration at the cut-outs in cross deck girder.		Notes on repairs 1. Fractured web plate of cross deck girder to be cropped and part renewed. 2. Collar plates to be provided.	

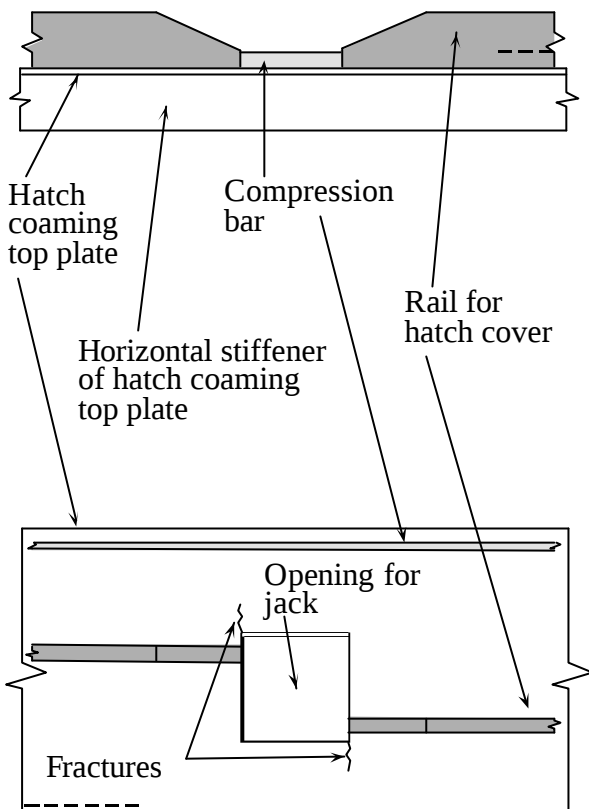
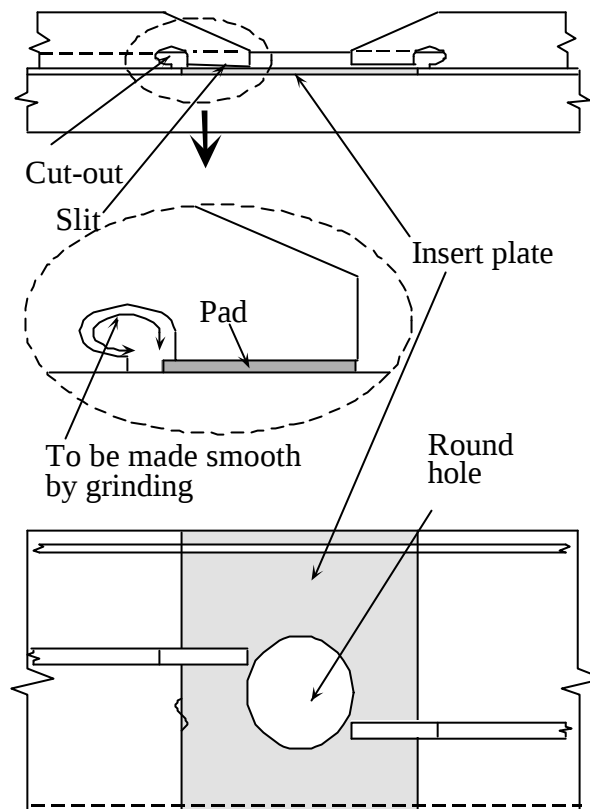
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		7-a
Detail of damage		Buckling of hatch coaming and hatch end beam	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Additional transverse forces due to heavy seas, and torsional loading. 2. Inadvertent overloading of cargo spaces.		Notes on repairs 1. If buckling is due to loss in strength induced by corrosion, the buckled zone to be cropped and renewed as necessary. 2. If buckling results from inadequate strength, stiffeners should be fitted in addition to cropping and renewal of buckled zone.	

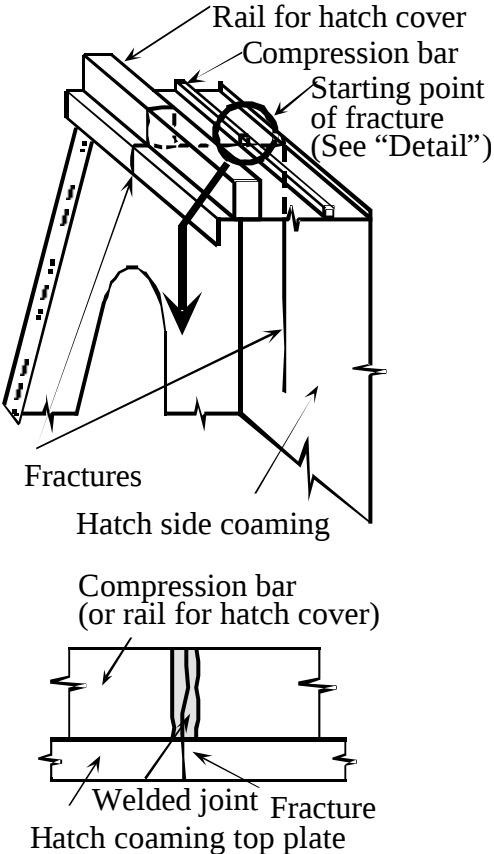
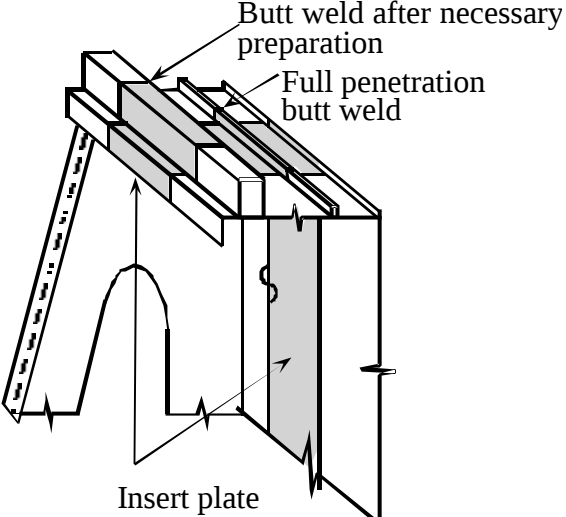
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		7-b
Detail of damage		Fractures in hatch end beam at knuckle joint	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Stress concentration at knuckle joint.		Notes on repairs 1. Fractured part to be cropped and renewed. 2. Improvement to avoid stress concentration at knuckle joint should be considered.	

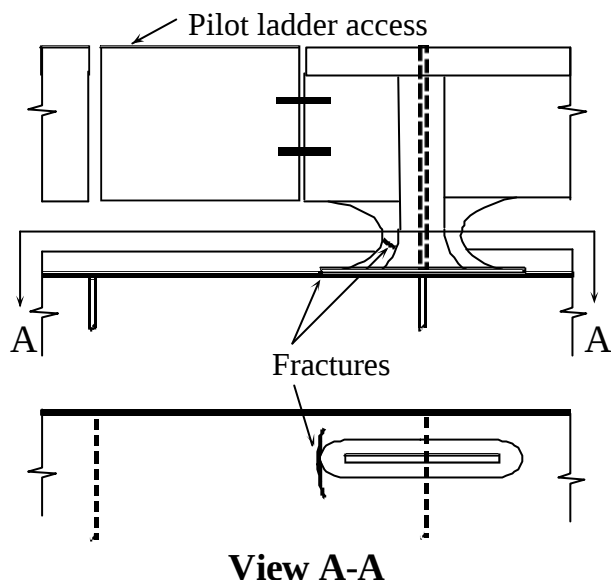
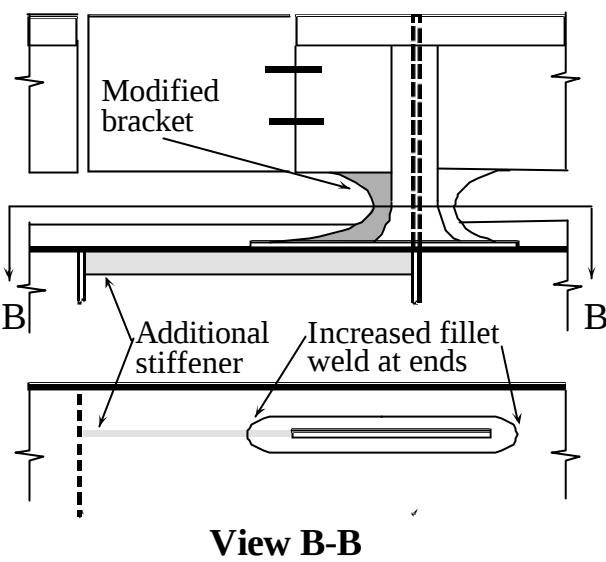
BULK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.
Area 1	Deck structure	8
Detail of damage	Fractures in hatch end beam at the joint to topside tank	
Sketch of damage 		Sketch of repair 
Notes on possible cause of damage 1. Misalignment of the hatch end beam with transverse web frame in topside tank. 2. Stress concentration.		Notes on repairs 1. Fractured part to be cropped and renewed.

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 1	Deck structure	9	
Detail of damage		Fractures in hatch end beam around feeding holes	
Sketch of damage		Sketch of repair	
 Topside tank Fractures around feeding holes		 Reinforcement of feeding holes by doubling plate or insert of pipe. See "Detail" below. Hatch end coaming Deck plating Insert of pipe Doubling plate Detail	
Notes on possible cause of damage		Notes on repairs	
1. Inadequate reinforcement around feeding hole. 2. Corrosion.		1. Fractured part to be veed-out or cropped and renewed. 2. If the fractured part is free from corrosion, reinforcement should be considered.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 1	Deck structure		10-a
Detail of damage		Fractures in hatch coaming top plate at the termination of rail for hatch cover	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Stress concentration at the termination of the rail for hatch cover due to poor design.		Notes on repairs 1. Fractured plate is to be cropped and part renewed. 2. Thicker insert plate and/or reinforcement by additional stiffener under the top plate should be considered. Also refer to Example 10-b.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure
Part 1	Cargo hold region	Example No.
Area 1	Deck structure	10-b
Detail of damage		Fractures in hatch coaming top plate at the termination of rail for hatch cover
Sketch of damage		Sketch of repair
 Hatch coaming top plate Compression bar Horizontal stiffener of hatch coaming top plate Rail for hatch cover Opening for jack Fractures		 Cut-out Slit Insert plate Pad To be made smooth by grinding Round hole
Notes on possible cause of damage		Notes on repairs
1. Stress concentration at the termination of the rail for hatch cover due to poor design of opening.		1. Fractured plate is to be cropped and part renewed. 2. Thicker insert plate and/or reduction of stress concentration adopting large radius should be considered. Or cut-out in the rail and detachment of the welds as shown in the above drawing should be considered in order to reduce the stress of the corner of the opening.

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure
Part 1	Cargo hold region	Example No.
Area 1	Deck structure	11
Detail of damage		Fractures in hatch coaming top plate initiated from butt weld of compression bar
Sketch of damage  Detail		Sketch of repair 
Notes on possible cause of damage 1. Heavy weather 2. Insufficient preparation of weld of compression bar and/or rail (Although the compression bar and rail are not longitudinal strength members, they subject same longitudinal stress as longitudinal members) 3. Crack may initiate from insufficient penetration of weld of rail for hatch cover.		Notes on repairs 1. Loading condition of the ship and proper welding procedure should be carefully considered. 2. Fractured structure is to be cropped and renewed if considered necessary. (Small fracture may be vee-d-out and rewelded.) 3. Full penetration welding should be applied to the butt weld of compression bar and rail.

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 1	Deck structure	12	
Detail of damage		Fractures in deck plating at the pilot ladder access of bulwarks	
Sketch of damage  Pilot ladder access Fractures View A-A		Sketch of repair  Modified bracket Additional stiffener Increased fillet weld at ends View B-B	
Notes on possible cause of damage 1. Stress concentration at the termination of bulwarks.		Notes on repairs 1. Fractured deck plating should be cropped and part renewed. 2. Reduction of stress concentration should be considered. In the above figure gusset plate was replaced with soft type for the fracture in gusset plate and pad plate was increased. Additional stiffeners were provided for the fracture in deck plating.	

Area 2 Topside tank structure

Contents

1 General

2 What to look for

- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 General comments on repair

- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

Figures and/or Photographs - Area 2	
No.	Title
Figure 1	Topside tank - Potential problem areas

Examples of structural detail failures and repairs - Area 2	
Example No.	Title
1	Fractures around unstiffened lightening holes and manholes in wash bulkhead
2-a	Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening
2-b	Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening
2-c	Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening
3	Fractures in transverse web at sniped end of stiffener
4-a	Fractures at slots in way of transverse web frame
4-b	Fractures and buckling at slots in way of transverse web frame
5	Fractures in longitudinal at transverse web frame or bulkhead
6	Fractures in the lowest longitudinal at transverse web frame
7-a	Fractures in transverse brackets
7-b	Fractures in transverse bracket
7-c	Fractures at toes of transverse bracket
8	Fractures in sloping plating and vertical strake initiated from the connection of topside tank to hatch end beam
9	Fractures in sloping plating at knuckle

Examples of structural detail failures and repairs - Area 2	
Example No.	Title
10	Fractures in way of collision bulkhead at intersection with topside tank structure in foremost cargo hold
11	Fractures in way of engine room forward bulkhead at intersection with topside tank structure in aftermost cargo hold

1 General

- 1.1** Topside tanks are highly susceptible to corrosion and wastage of the internal structure. This is a major problem for all bulk carriers, particularly for ageing ships and others where the coatings have broken down. Coatings, if applied and properly maintained, serve as an indication as to whether the structure remains in satisfactory condition and highlights any structural defects.

In some ships topside tanks are protected by sacrificial anodes in addition to coatings. This system is not effective for the upper parts of the tanks since the system requires the structure to be fully immersed in sea water, and the tanks may not be completely filled during ballast voyages.

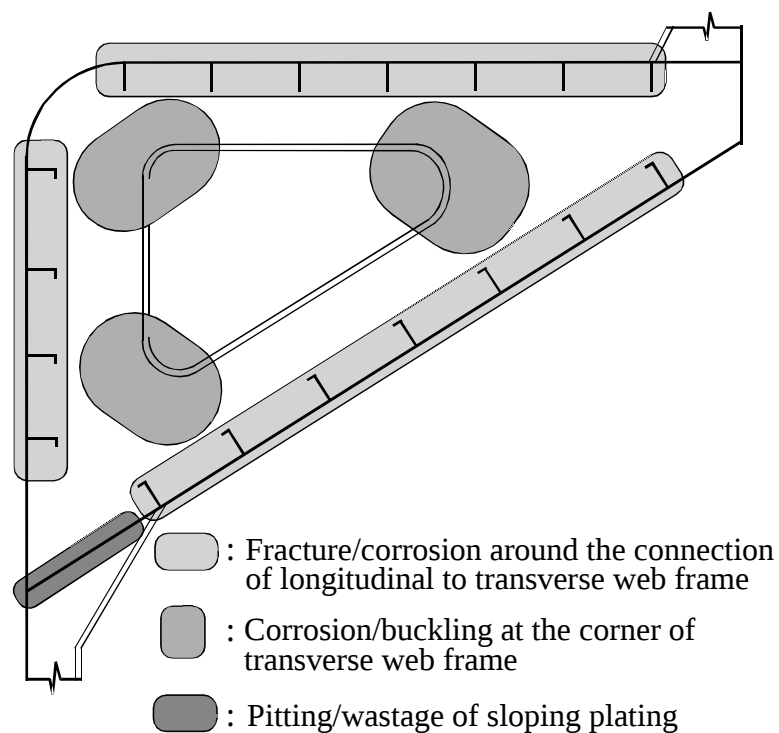
Other major factors contributing to damages of the topside tank structure are those associated with overpressurisation and sloshing in partially filled adjacent ballast tanks / holds due to ship rolling in heavy weather.

- 1.2** Termination of longitudinals in the fore and aft regions of the ship, in particular at the collision and engine room bulkheads, is prone to fracture due to high stress concentration if the termination detail is not properly designed. Knuckle joint in topside tanks in the fore and aft regions of the ship may suffer from fractures if the structure is not properly reinforced, see **Example 10**.

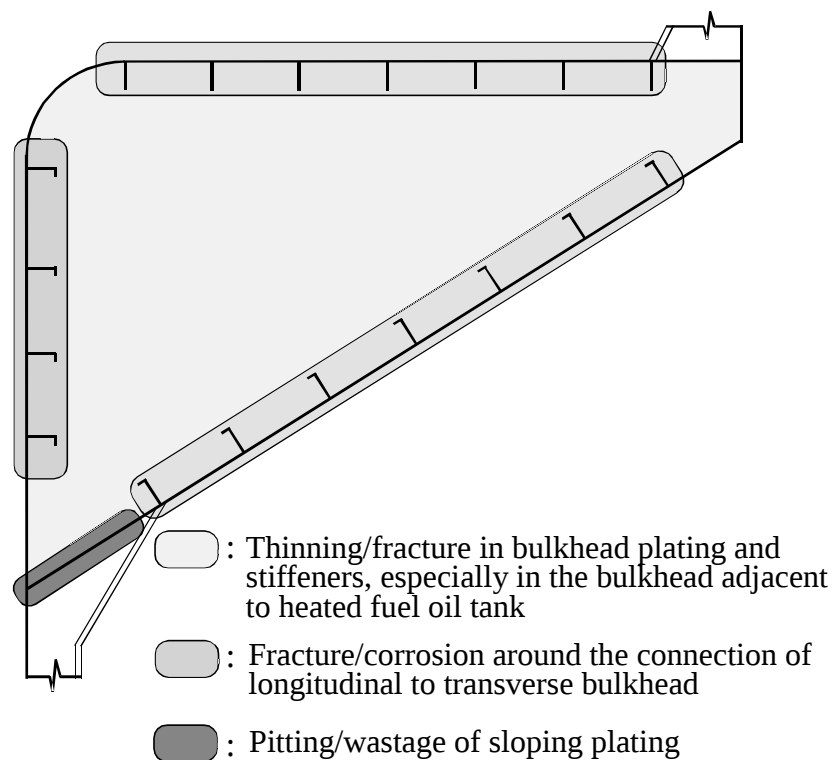
2 What to look for

2.1 Material wastage

- 2.1.1** The combined effect of the marine environment and the high humidity atmosphere within a topside tank hold will give rise to a high corrosion rate.
- 2.1.2** Rate and extent of corrosion depends on the environmental conditions, and protective measures employed, such as coatings and sacrificial anodes. The following structures are generally susceptible to corrosion (See **Figure 1**).
- (a) Structure in corrosive environment
 - Deck plating and deck longitudinal
 - Transverse bulkhead adjacent to heated fuel oil tank
 - Lowest part of sloping plating
 - (b) Structure subject to high stress
 - Face plates and web plates of transverse at corners
 - Connection of side longitudinal to transverse
 - (c) Areas susceptible to coating breakdown
 - Back side of face plate of longitudinal
 - Welded joint
 - Edge of access opening
 - (d) Areas subjected to poor drainage
 - Web of side and sloping longitudinals



(a) Transverse web frame section



(b) Transverse bulkhead section

Figure 1 Topsides tank - Potential problem areas

2.2 Deformations

2.2.1 Deformation of structure may be caused by contact (with quay side, ice, touching underwater objects, etc.), collision, mishandling of cargo and high stress. Attention should be paid to the following areas during inspection::

- (a) Structure subjected to high stress
 - Buckling of transverse webs at corners
- (b) Structure adjacent to a ballast hold
 - Deformations may be found in the following structural members caused by sloshing in partially filled ballast hold and/or by improper carriage of ballast water (See Note):
 - Buckling of transverse web and/or collapse of transverse attached to sloping plating
 - Deformation of sloping plating and/or collapse of sloping plating longitudinals
 - Buckling of diaphragm, if provided

Note: In some bulk carriers the topside tanks in way of a ballast hold are designed to be filled when the hold is used for the carriage of water ballast. In such ships, if the topside tanks are not filled in the ballast condition, the structural members in the topside tanks may suffer fracture/deformation as a result of increased stress.

2.2.2 Improper ventilation during ballasting/deballasting of topside tank/ballast hold may cause deformation in deck structure and damage to topside tank structure. If such deformation is observed during on-deck inspection, internal inspection of topside tank should be carried out in order to confirm the nature and the extent of damage.

2.3 Fractures

2.3.1 Attention should be paid to the following areas during inspection for fracture damage:

- (a) Areas subjected to stress concentration
 - Welded joints of face plate of transverse at corners
 - Connection of sniped ends of stiffener to transverse web, near or at corners of the transverse
 - Connection of the lowest longitudinal to transverse web frame, especially with reduced scantlings (See **Example 6**).
 - Termination of longitudinal in fore and aft topside tanks
 - Knuckle joint of sloping plating in foremost and aftermost topside tanks (See **Example 9**).
 - Transition regions in foremost and aftermost topside tanks (Refer to **2.3.2**)
 - Connection in line with hold transverse bulkhead corrugations and transverse stools
 - Connection in line with the side shell transverse framing, and end brackets, particularly at the bracket toes
- (b) Areas subjected to dynamic wave loading
 - Connection of side longitudinal to watertight bulkhead
 - Connection of side longitudinal to transverse web frame

2.3.2 The termination of the following structural members at the collision bulkhead or engine room forward bulkhead is prone to fracture damage due to discontinuity of the structure:

- Topside tank sloping plating
- Topside tank plating vertical strake
- Fore peak tank top plating (Boatswain's store deck plating)
- Longitudinal bulkhead of fuel tank in engine room

In order to avoid stress concentration due to discontinuity appropriate stiffeners are to be provided in the opposite space. If such stiffeners are not provided, or are deficient due to corrosion or misalignment, fractures may occur at the terminations.

3 General comments on repair

3.1 Material wastage

3.1.1 If the corrosion is caused by high stress concentration, renewal with original thickness is not sufficient to avoid reoccurrence.

Renewal with increased thickness and/or appropriate reinforcement should be considered in conjunction with appropriate corrosion protective measures.

3.2 Deformations

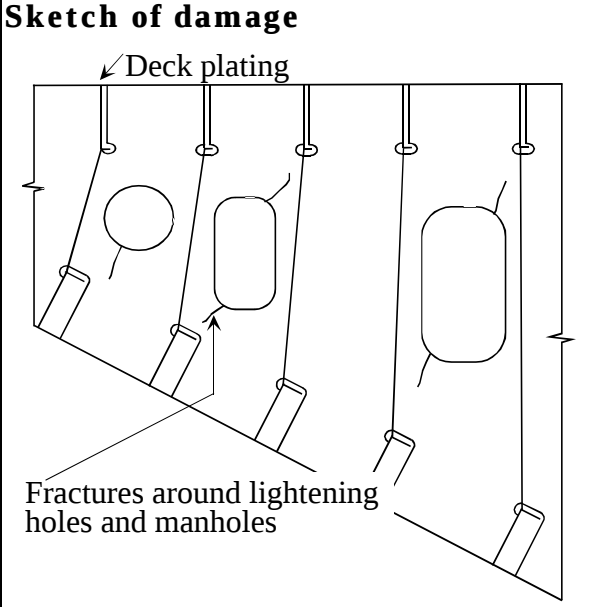
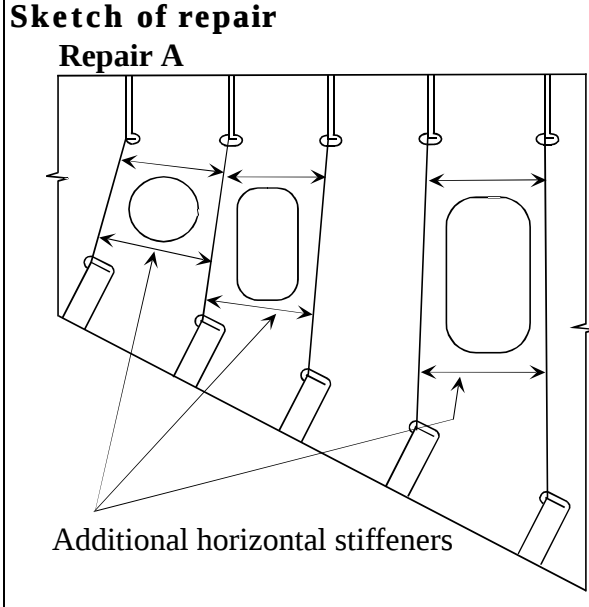
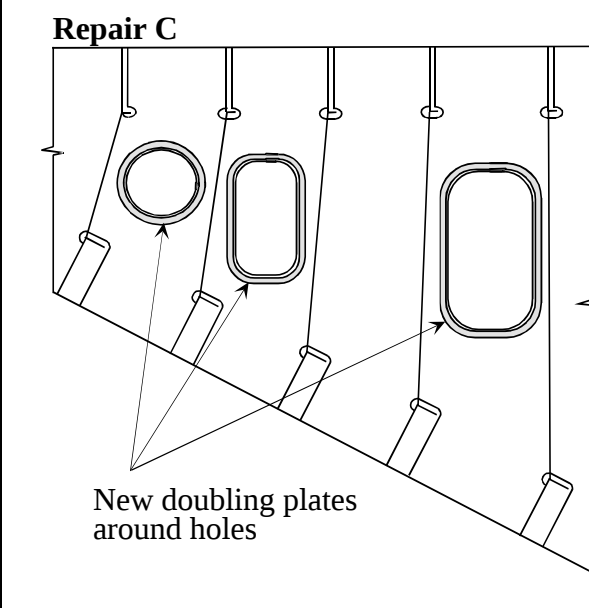
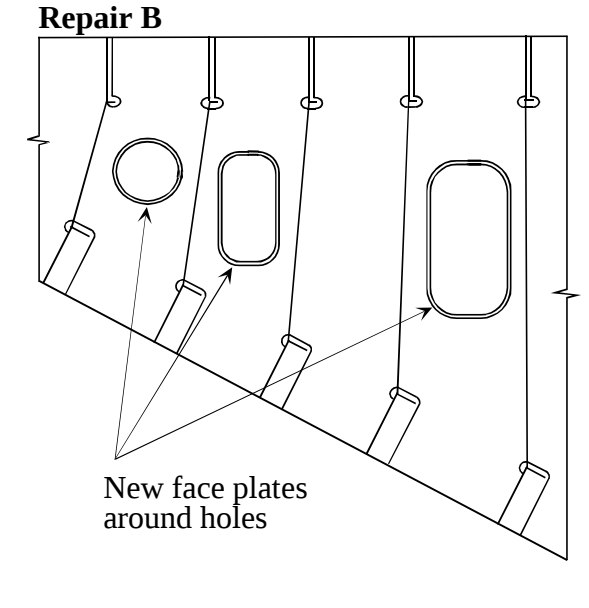
3.2.1 The cause of damage should always be identified. If the damage is due to negligence in operation, the ship representative should be notified. If the deformation is caused by inadequate structural strength, appropriate reinforcement should be considered. Where the deformation is related to corrosion, appropriate corrosion protective measures should be considered.

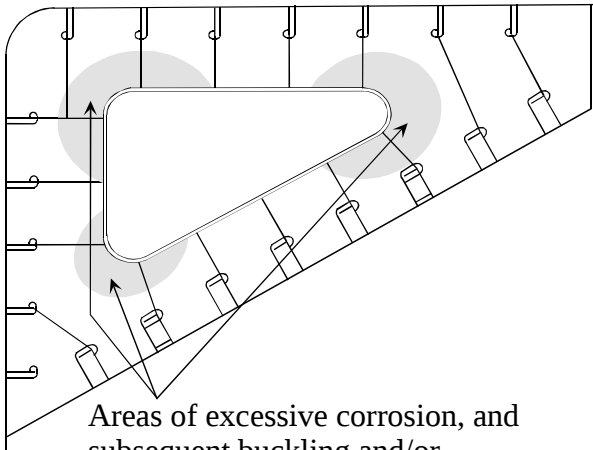
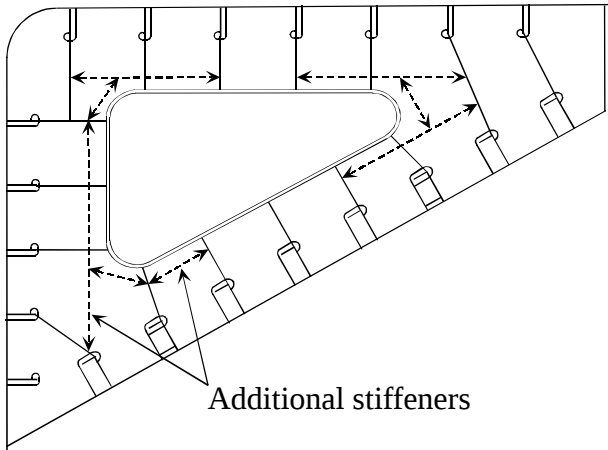
3.3 Fractures

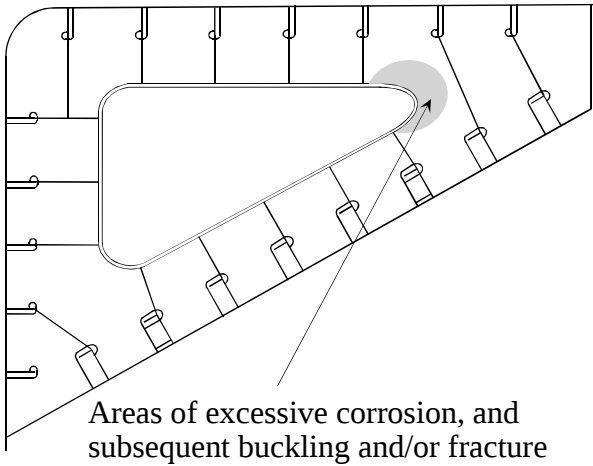
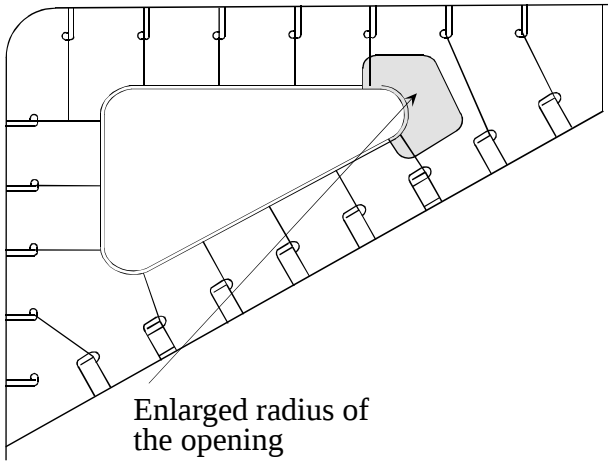
3.3.1 If the cause of the fracture is fatigue under the action of cyclic wave loading, consideration should be given to the improvement of structural detail design, such as provision of soft toe bracket, to reduce stress concentration. If the fatigue fracture is vibration related, the damage is usually associated with moderate stress levels at high cycle rate, improvement of structural detail may not be effective. In this case, measures for increasing structural damping and avoidance of resonance, such as providing additional stiffening, may be considered.

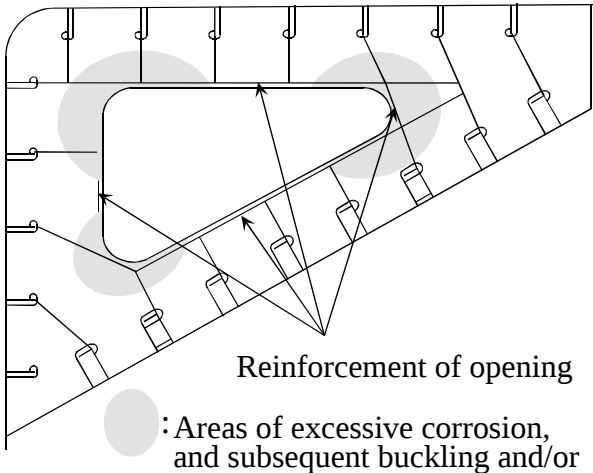
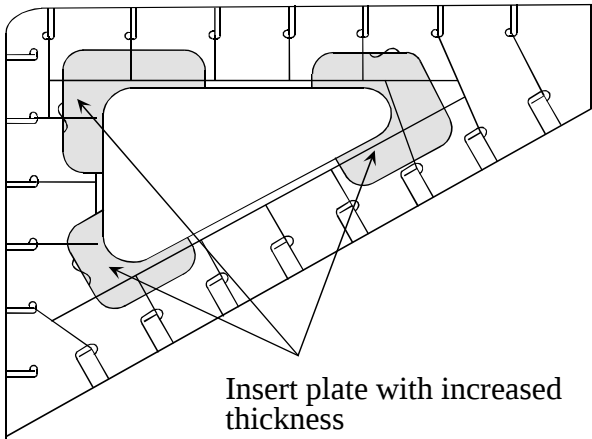
Where fracture occurs due to material under excessive stress, indicating inadequate structural strength, renewal with thicker plate and/or providing appropriate reinforcement should be considered.

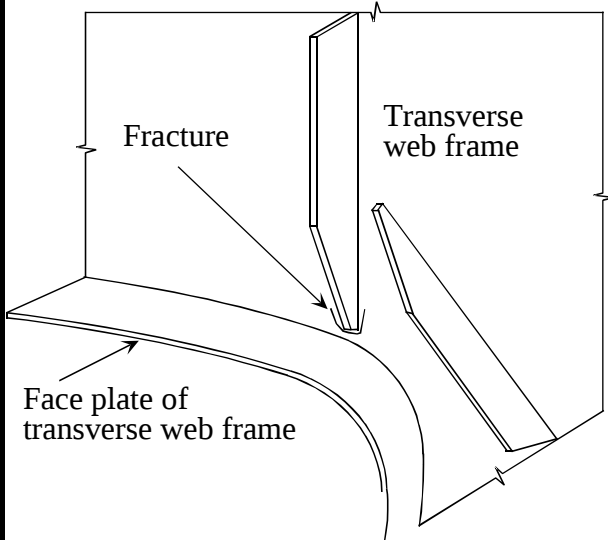
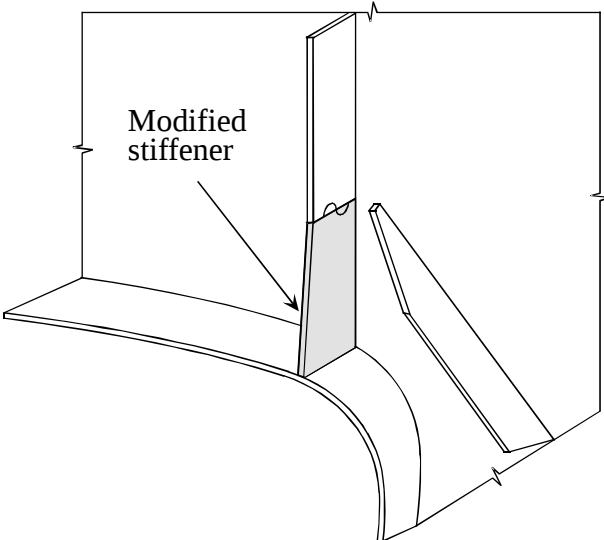
Where fracture is found in the transition region, measures for reducing the stress concentration due to structural discontinuity should be considered.

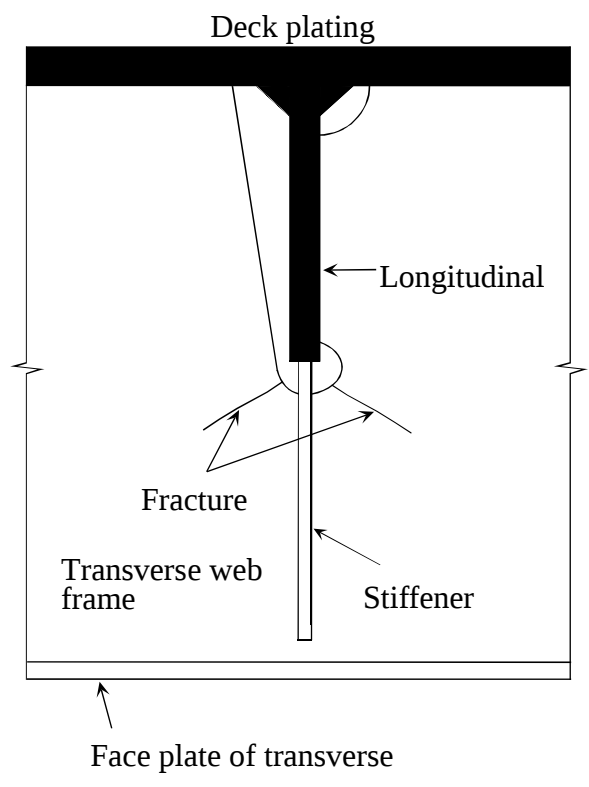
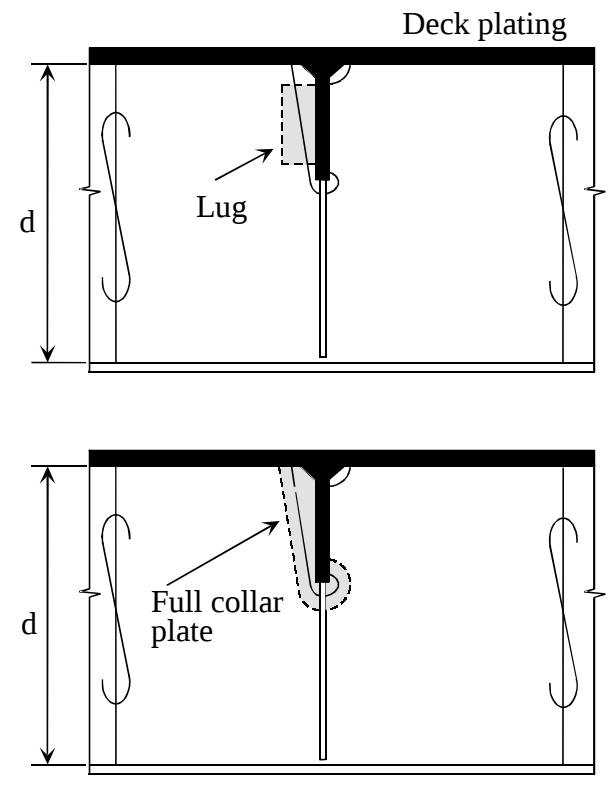
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	1	
Detail of damage		Fractures around unstiffened lightening holes and manholes in wash bulkhead	
Sketch of damage		Sketch of repair	
		Repair A 	
Repair C 		Repair B 	
Notes on possible cause of damage		Notes on repairs	
General levels of corrosion and presence of stress concentration.		- Corroded/fractured plate should be cropped and renewed with plating of enhanced thickness. - Reinforcement should be considered.	

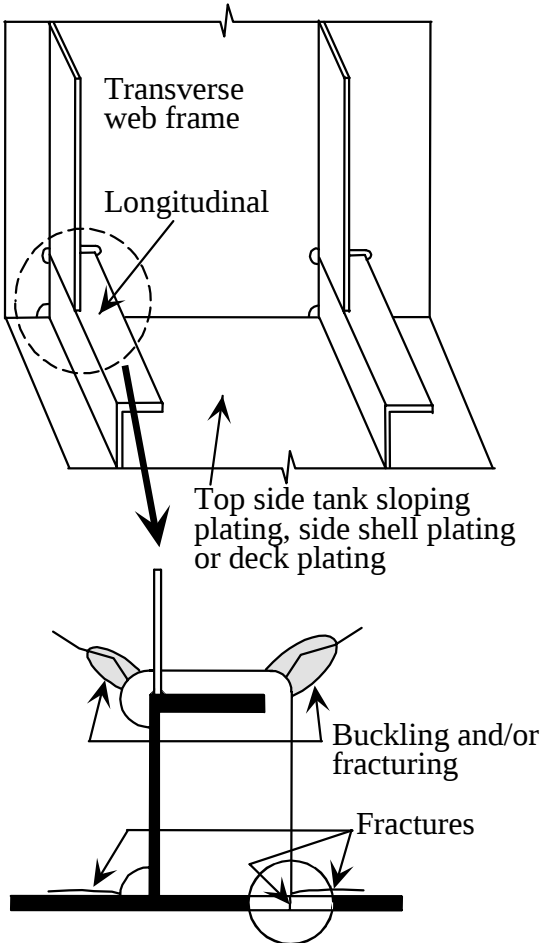
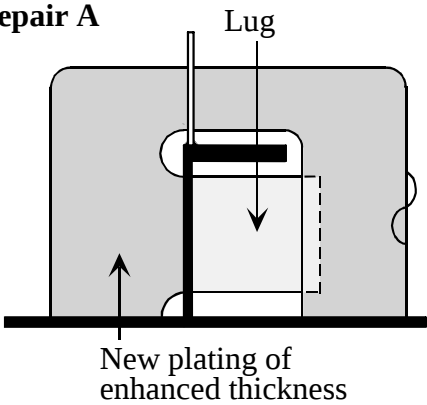
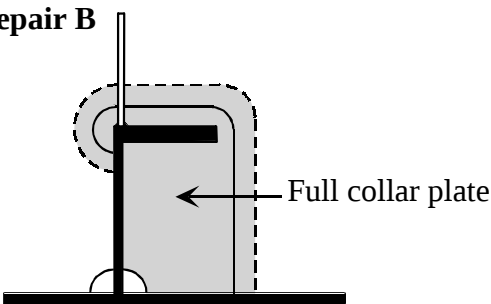
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	2-a	
Detail of damage		Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening	
Sketch of damage		Sketch of repair	
 Areas of excessive corrosion, and subsequent buckling and/or		 Additional stiffeners	
Notes on possible cause of damage 1. Insufficient buckling strength. 2. Corrosion due to stress concentration at corners.		Notes on repairs 1. Buckled plating is to be cropped and parts renewed, if necessary. 2. Additional stiffeners as shown above and/or renewal with plating of increased thickness should be considered.	

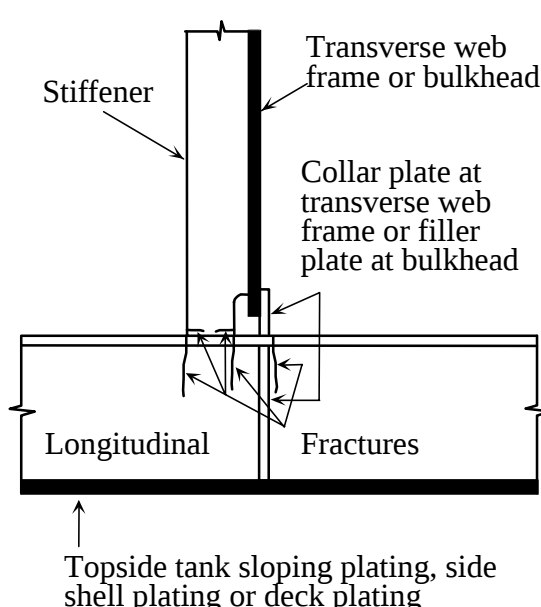
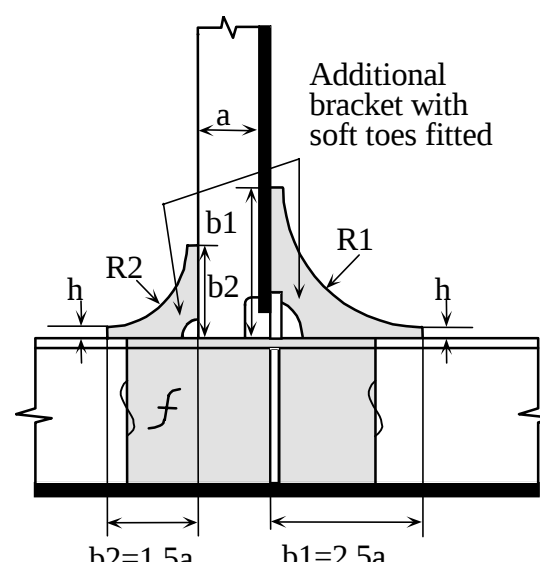
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	2-b	
Detail of damage		Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening	
Sketch of damage		Sketch of repair	
 Areas of excessive corrosion, and subsequent buckling and/or fracture		 Enlarged radius of the opening	
Notes on possible cause of damage		Notes on repairs	
Corrosion caused by stress concentration at the corner due to insufficient radius for the opening.		- Corroded/buckled plating is to be cropped and parts renewed with plating of increased thickness and additional stiffeners are preferable to minimize deflection. - An attempt should be made to improve the design of the radius if felt necessary.	

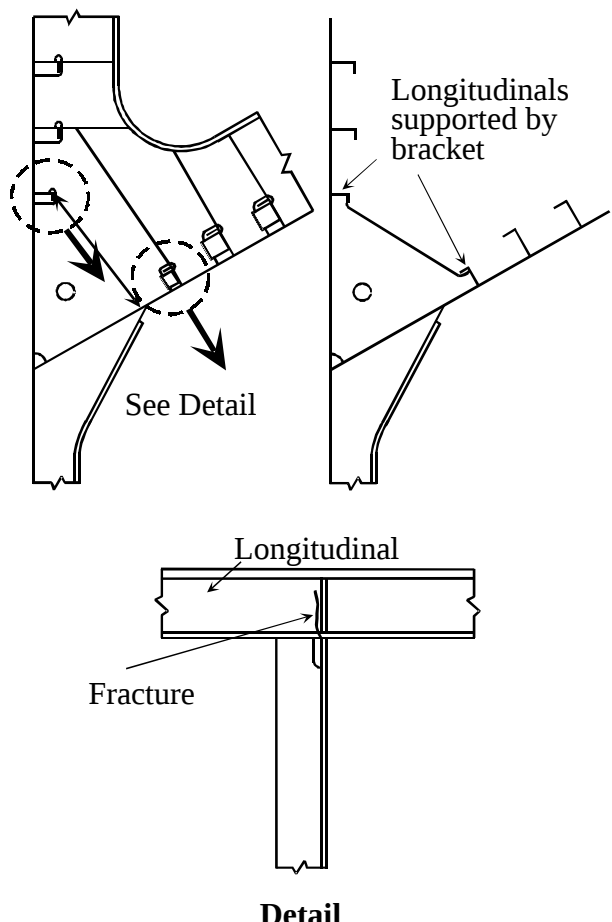
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	2-c	
Detail of damage		Thinning and subsequent buckling of web plating in the vicinity of the radii of the opening	
Sketch of damage		Sketch of repair	
 Reinforcement of opening : Areas of excessive corrosion, and subsequent buckling and/or		 Insert plate with increased thickness	
Notes on possible cause of damage		Notes on repairs	
1. Additional stresses at the free edge of transverse web. (In Example 2-a - 2-c face plate is provided for the reinforcement of the opening.)		1. Corroded/buckled plating is to be cropped and part renewed with plating of increased thickness.	

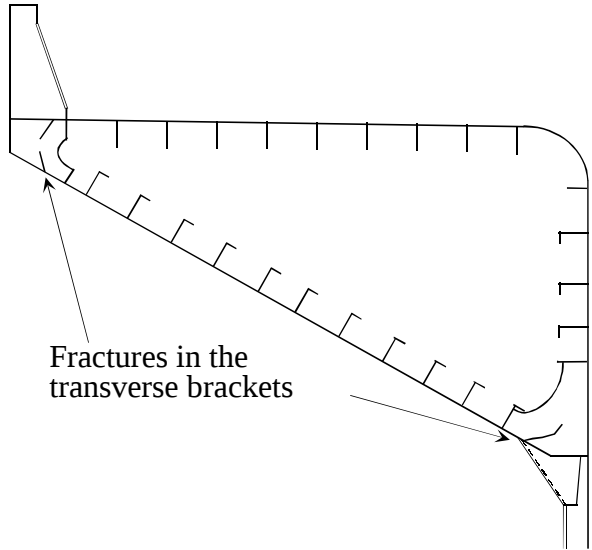
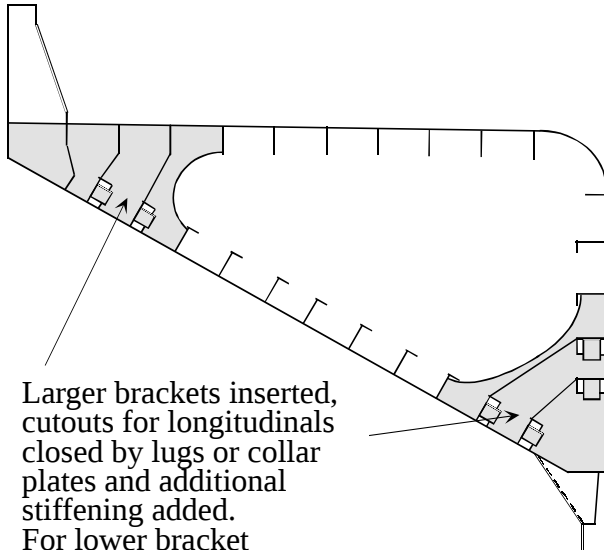
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	3	
Detail of damage		Fractures in transverse web at sniped end of stiffener	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Stress concentration.		1. Fracture can be vee-d out and welded provided the plating is not generally corroded. If necessary, fractured plating should be cropped and renewed. 2. Excessive stress concentration at the end of stiffener should be avoided.	

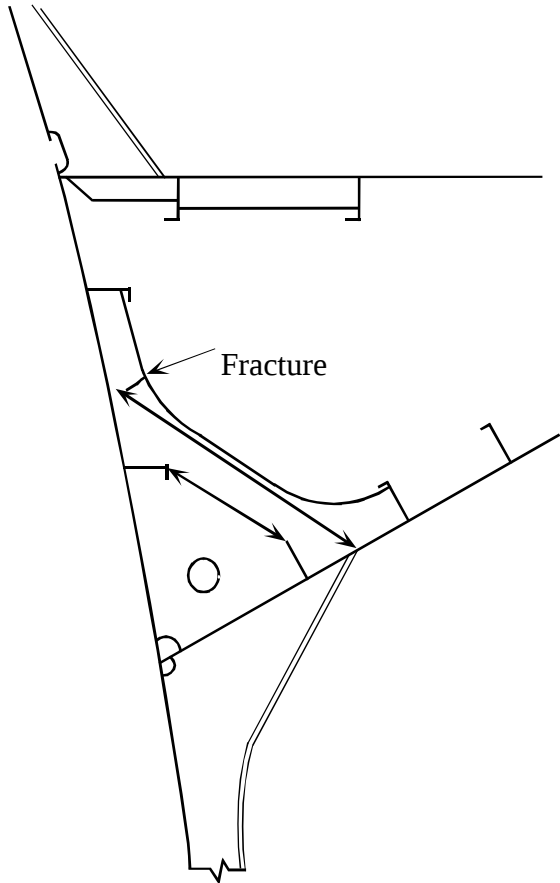
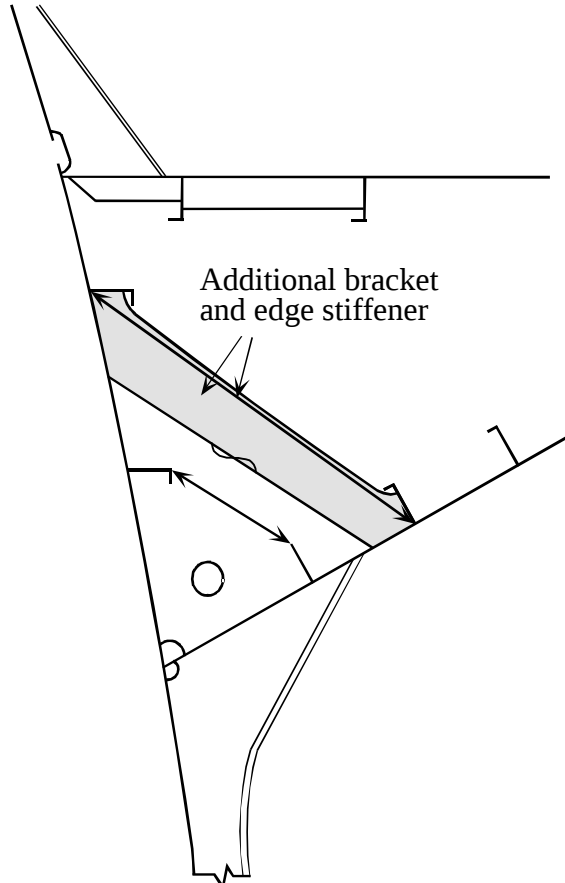
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	4-a	
Detail of damage		Fractures at slots in way of transverse web frame	
Sketch of damage		Sketch of repair	
		 (Note) Full collar plate where the depth of cut-out is more than 0.4 times the depth of web frame ($0.4d$) and in an areas of high shear stress	
Notes on possible cause of damage		Notes on repairs	
1. Damage may be created by local shear stress concentrations due to large cut-outs for notch. 2. Also deficient welds (fillet welds between deck longitudinal and stiffener).		1. Crop and part renew the web plating. 2. Close the cut-out by introducing a lug or alternatively fit a full collar plate.	

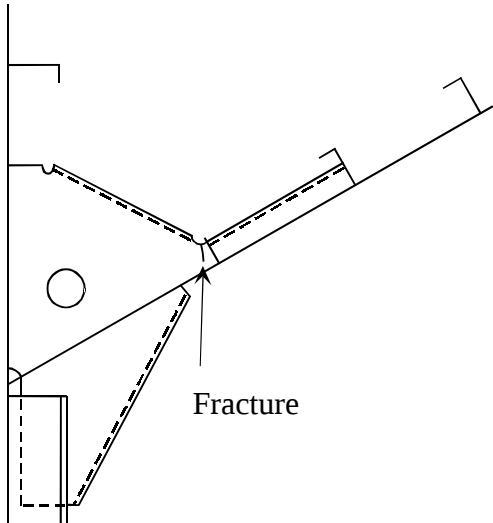
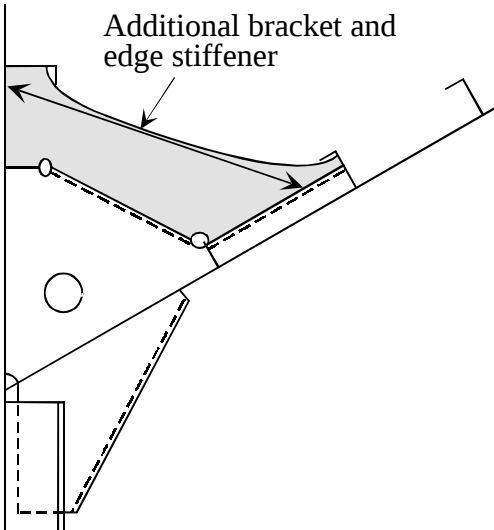
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	4-b	
Detail of damage		Fractures and buckling at slots in way of transverse web frame	
Sketch of damage		Sketch of repair	
 Transverse web frame Longitudinal Top side tank sloping plating, side shell plating or deck plating Buckling and/or fracturing Fractures		Repair A  Lug New plating of enhanced thickness Repair B  Full collar plate	
Notes on possible cause of damage		Notes on repairs	
1. Damage can be caused by general levels of corrosion and presence of stress concentration associated with the presence of a cut-out.		1. If fractures are significant then crop and part renew the plating otherwise the fracture can be veed-out and welded provided the plating is not generally corroded. 2. Repair A Lug should be considered. 3. Repair B Full collar plate should be considered where the depth of cut-out is more than 0.4 times the depth of web frame and in an area of high shear stress or the existing lug proves to be ineffective.	

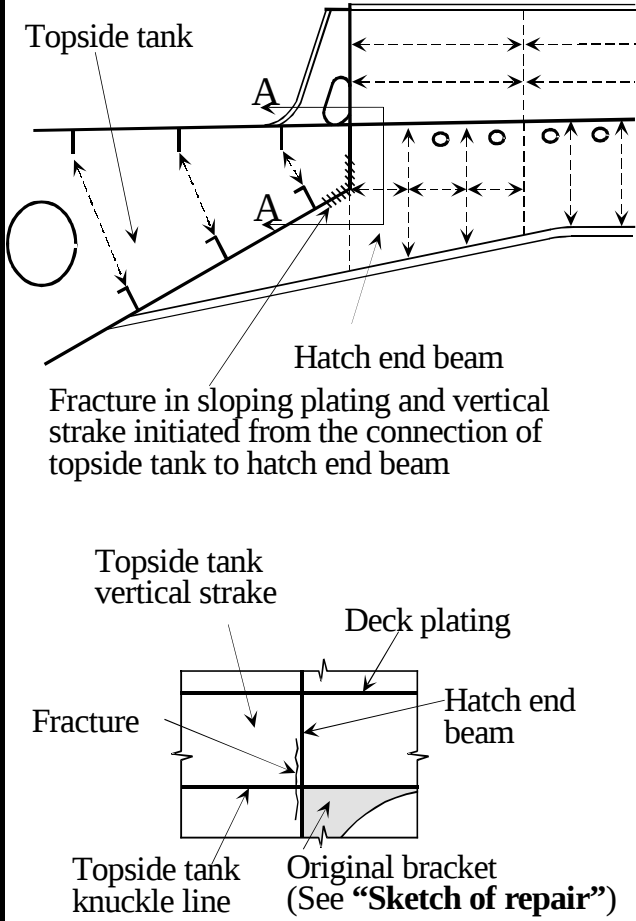
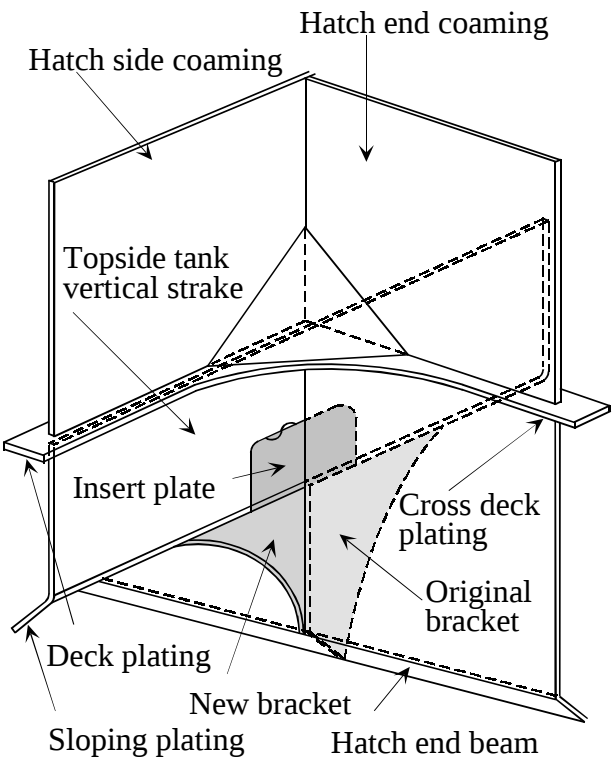
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure
Part 1	Cargo hold region	Example No.
Area 2	Topside tank structure	5
Detail of damage Fractures in longitudinal at transverse web frame or bulkhead		
Sketch of damage 		Sketch of repair  f: Where required, the longitudinal to be cropped and part renewed 1. For a slope at toes max. 1:3, $R1 = (b1 - h) \times 1.6$ and $R2 = (b2 - h) \times 1.6$ 2. Soft toe bracket to be welded first to longitudinal 3. Scallop in bracket to be as small as possible, recommended max. 35mm 4. If toes of brackets are ground smooth, full penetration welds in way to be provided 5. Maximum length to thickness ratio = 50:1 for unstiffened bracket edge 6. Toe height, h, to be as small as possible (10-15mm)
Notes on possible cause of damage 1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.		Notes on repairs 1. If fracture extends to over one third of the depth of the longitudinal, then crop and part renew. Otherwise the fracture can be veed-out and welded.

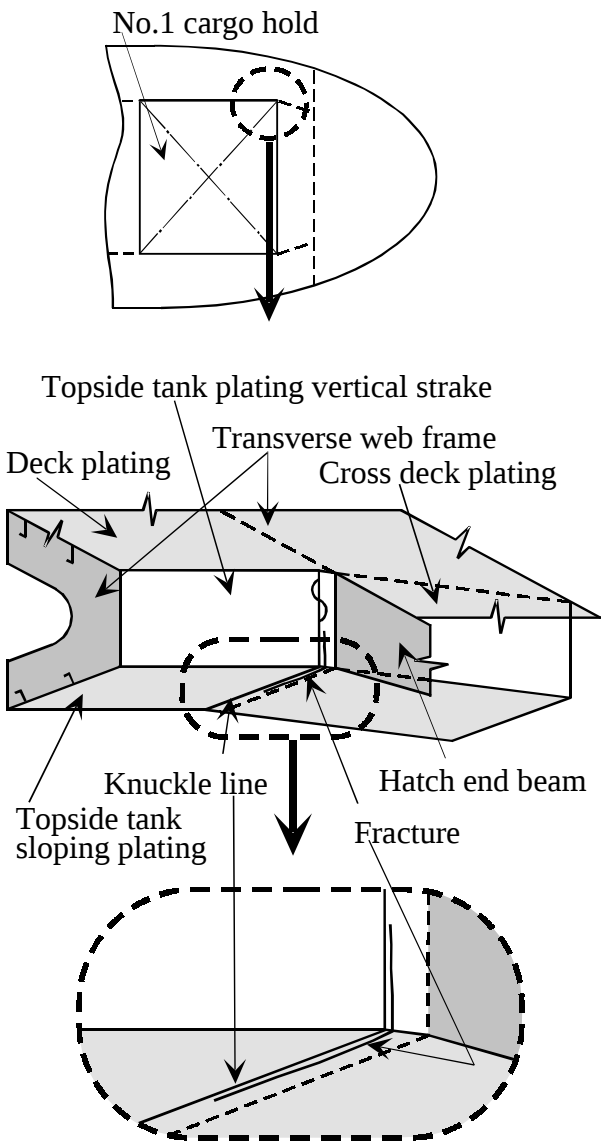
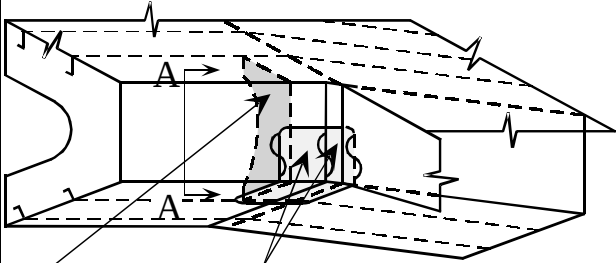
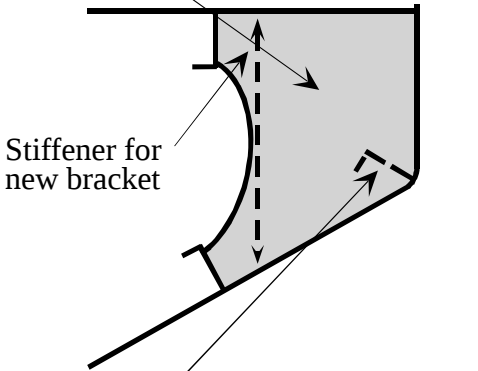
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	6	
Detail of damage		Fractures in the lowest longitudinal at transverse web frame	
Sketch of damage			
Notes on possible cause of damage		Notes on repairs 1. Insufficient scantling for torsional rigidity (The lowest longitudinal is usually supported by bracket(s) as shown in the above and smaller scantling may be adopted. However, the lowest longitudinal undergoes torsion from side shell frame through bracket(s) and may suffer fracture.) 1. Fractured part to be cropped and renewed. 2. Size of bracket should be increased	

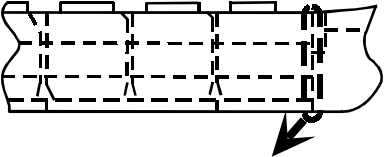
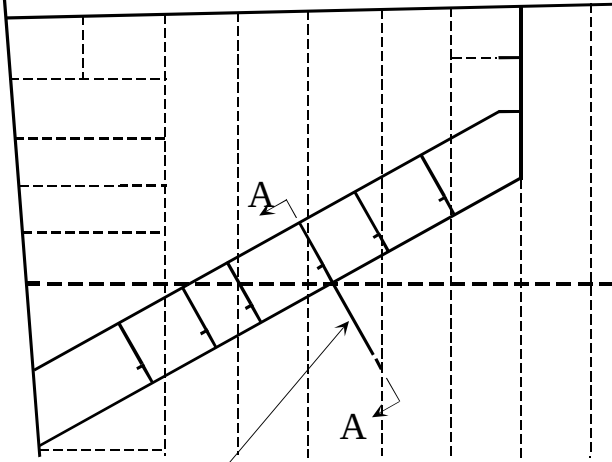
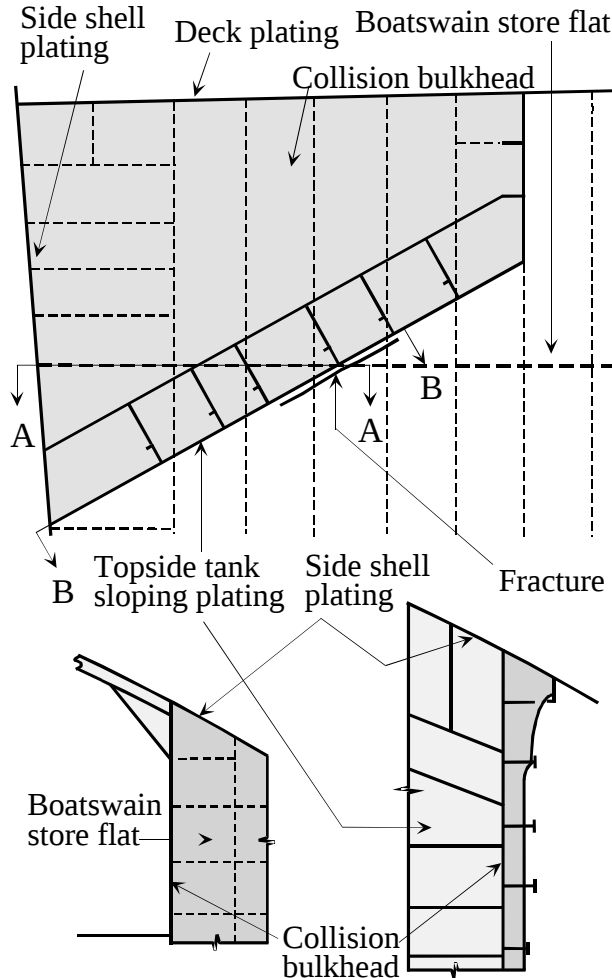
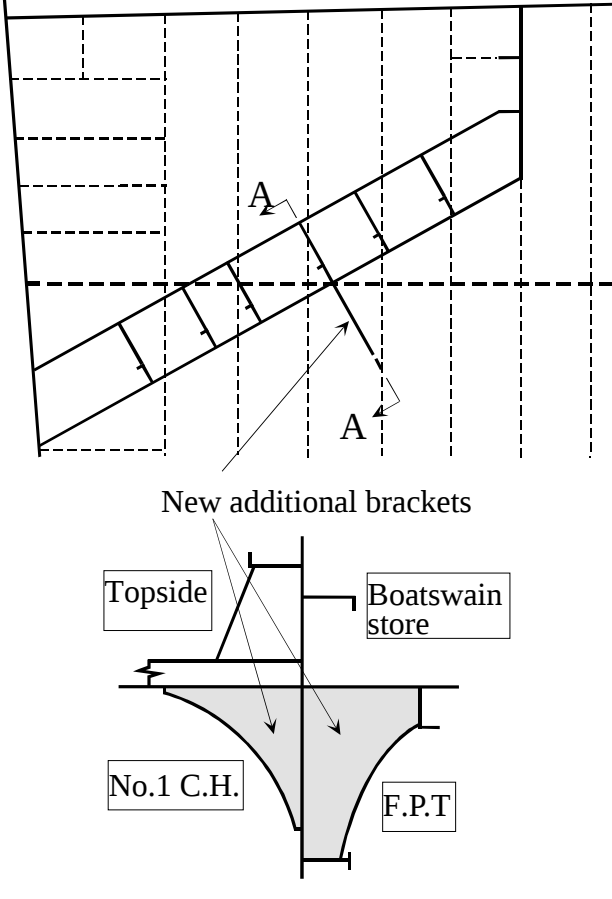
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	7-a	
Detail of damage		Fractures in transverse brackets	
Sketch of damage		Sketch of repair	
 Fractures in the transverse brackets		 Larger brackets inserted, cutouts for longitudinals closed by lugs or collar plates and additional stiffening added. For lower bracket alternatively increase the thickness	
Notes on possible cause of damage		Notes on repairs	
1. General levels of corrosion and presence of stress concentrations. 2. Misalignment of the brackets with adjoining structure, e.g. side shell frame brackets and/or coaming brackets. 3. High shear stresses due to insufficient bracket size. 4. Inadvertent overloading.		1. If the damage is caused by misalignment with the side shell frame brackets or the hatch coaming brackets the misalignment is to be rectified and the replacement by larger brackets incorporated only if considered necessary.	

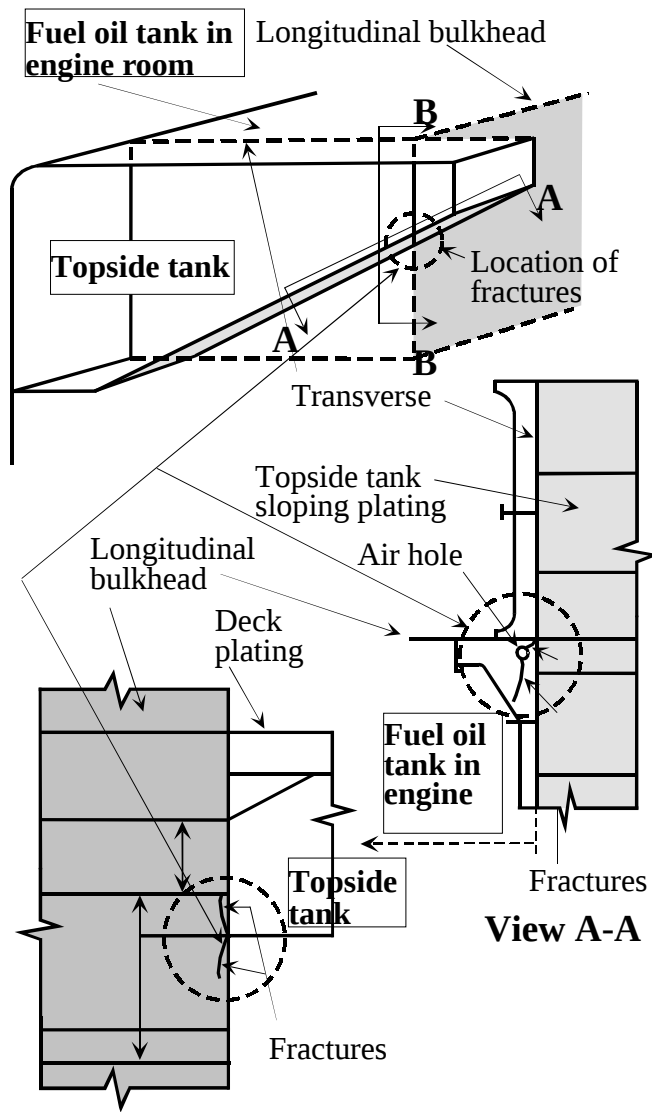
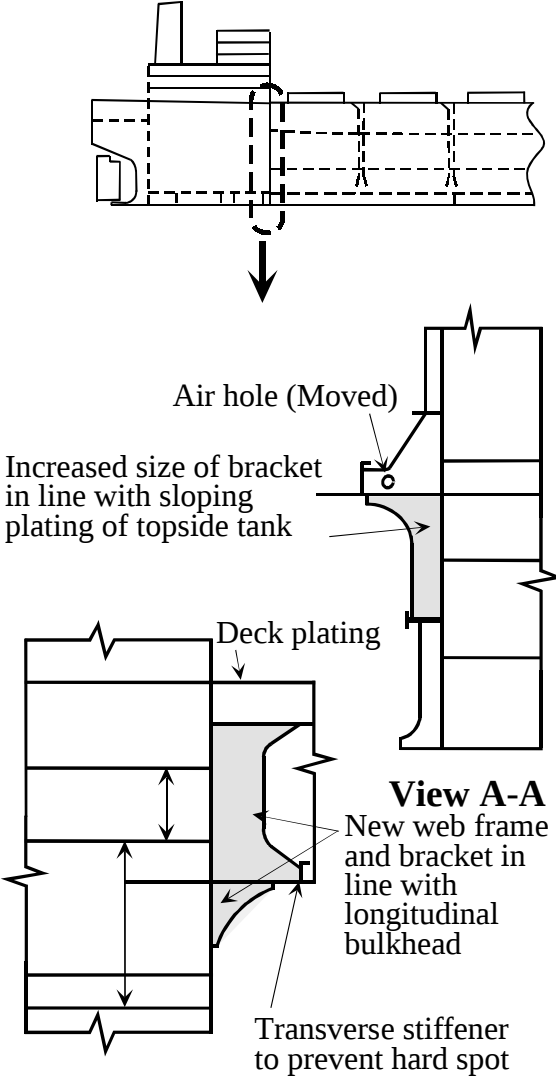
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	7-b	
Detail of damage		Fractures in transverse bracket	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Insufficient strength. 2. Corrosion.		1. Fractured part to be cropped and renewed. 2. If the fractured part is free from corrosion, increased size and thickness should be considered. Partial renewal of the bracket may be accepted depending on the nature of the fracture.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	7-c	
Detail of damage		Fractures at toes of transverse bracket	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Stress concentration due to the shape of the bracket.		1. Cracked weld to be veed-out and rewelded.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 2	Topside tank structure	8	
Detail of damage		Fractures in sloping plating and vertical strake initiated from the connection of topside tank to hatch end beam	
Sketch of damage  Topside tank Hatch end beam Fracture in sloping plating and vertical strake initiated from the connection of topside tank to hatch end beam Topside tank vertical strake Deck plating Fracture Hatch end beam Topside tank knuckle line Original bracket (See "Sketch of repair") View A-A		Sketch of repair  Hatch side coaming Hatch end coaming Topside tank vertical strake Insert plate Cross deck plating Original bracket Deck plating New bracket Sloping plating Hatch end beam	
Notes on possible cause of damage 1. Stress concentration at the connection of hatch end beam to topside tank.		Notes on repairs 1. Fractured part to be cropped and renewed with increased thickness. 2. Additional bracket should be considered for reinforcement.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure
Part 1	Cargo hold region	Example No.
Area 2	Topside tank structure	9
Detail of damage		Fractures in sloping plating at knuckle
Sketch of damage  No.1 cargo hold Topside tank plating vertical strake Deck plating Transverse web frame Cross deck plating Knuckle line Hatch end beam Topside tank sloping plating Fracture		Sketch of repair  New additional bracket (See View A-A) Insert plates should be assembled where welding is easy to be performed before inserted in topside tank for quality of butt welded joint and the joint should be grounded.  Stiffener for new bracket Insert plate provided between new additional bracket and adjacent original transverse web frame View A-A
Notes on possible cause of damage 1. Insufficient strength. 2. Additional stress induced by knuckle.		Notes on repairs 1. Knuckle part should be reinforced appropriately.

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure
Part 1	Cargo hold region	Example No.
Area 2	Topside tank structure	10
Detail of damage		Fractures in way of collision bulkhead at intersection with topside tank structure in foremost cargo hold
Sketch of damage 		Sketch of repair 
 Side shell plating Deck plating Boatswain store flat Collision bulkhead Section A-A Section B-B		 New additional brackets Topside Boatswain store No.1 C.H. F.P.T. Section A-A
Notes on possible cause of damage 1. Damage caused by hard spot at intersection of the topside tank sloping plating and boatswain's store deck plating (fore peak tank top plating).		Notes on repairs 1. Fractured plates to be cropped and renewed. 2. Stress concentration should be considered (Brackets were fitted on both sides for reinforcement).

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure
Part 1	Cargo hold region	Example No.
Area 2	Topside tank structure	11
Detail of damage		Fractures in way of engine room forward bulkhead at intersection with topside tank structure in aftermost cargo hold
Sketch of damage		Sketch of repair
		
Notes on possible cause of damage		Notes on repairs
1. Damage caused by hard spot at intersection of the topside tank sloping plating and longitudinal bulkhead of the fuel oil tank in engine room.		1. Fractured plates to be cropped and renewed as necessary and reinforcement fitted as shown shaded above. The position of the air-hole to be relocated.

Area 3 Cargo hold side structure

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- 2.2 Deformations
- 2.3 Fractures

3 What to look for - External inspection

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- 3.2 Deformations
- 3.3 Fractures

4 General comments on repair

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- 4.2 Deformations
- 4.3 Fractures

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No.	Title
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Figure 2	Damages to side shell frame - Potential problem areas
Figure 3	Representative gauging locations on the side shell frame - Potential problem areas
Figure 4	Transition regions - Potential problem areas
Figure 5	Uniform corrosion of side shell frame
Photograph 1	Collapsed side shell frames
Photograph 2	Missing side shell structure

Examples of structural detail failures and repairs - Area 3	
Example No.	Title
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1-b	Fractures in side shell frame at bracket's toe
2	Fractures in side shell frame at bracket's toe
3	Fractures in side shell frame/lower bracket and side shell plating near hopper
4	Deformation of side shell plating
5	Adverse effect of corrosion on the frame of forward/afterward hold

Examples of structural detail failures and repairs - Area 3	
Example No.	Title
6	Buckling and fractures of side shell plating in foremost cargo hold
7	Fractures at the supporting brackets in way of the collision bulkhead
8	Fractures at the supporting brackets in way of the collision bulkhead with no side shell panting stringer in hold
9	Fractures in way of horizontal diaphragm in the connecting trunk between topside tank and hopper double bottom tank, on after side of collision bulkhead
10	Fractures in way of continuation/extension bracket in aftermost hold at the engine room bulkhead

1 General

- 1.1 In addition to contributing to the shear strength of the hull girder, the side shell forms the external boundary of a cargo hold and is naturally the first line of defense against ingress/leakage of sea water when the ship hull is subjected to wave and other dynamic loading in heavy weather. The integrity of the side structure is of prime importance to the safety of the ship and this warrants very careful attention during survey and inspection.
- 1.2 The ship side structure is prone to damage caused by contact with the quay during berthing and impacts of cargo and cargo handling equipment during loading and discharging operations.
- 1.3 The marine environment in association with the handling and characteristics of certain cargoes (e.g. wet timber loaded from sea water and certain types of coal) may result in deterioration of coating and severe corrosion of plating and stiffeners. This situation makes the structure more vulnerable when exposed to heavy weather.
- 1.4 Bulk carriers carry various cargoes and one of the common cargoes is coal, especially for large bulk carriers. Certain types of coal contains sulphur impurities and when they react with water produce sulfuric acid which can cause severe corrosion to the structure if suitable coating is not applied and properly maintained.
- 1.5 The structure at the transition regions at the fore and aft ends of the ship are subject to stress concentrations due to structural discontinuities. The side shell plating at the transition regions is also subject to panting. The lack of continuity of the longitudinal structure, and the increased slenderness and flexibility of the side structure, makes the structure at the transition regions more prone to fracture damages.
- 1.6 A summary of potential problem areas is shown in **Figures 1 - 4**. Examples of failure and damaged ship side structure are illustrated in **Photographs 1- 2**.

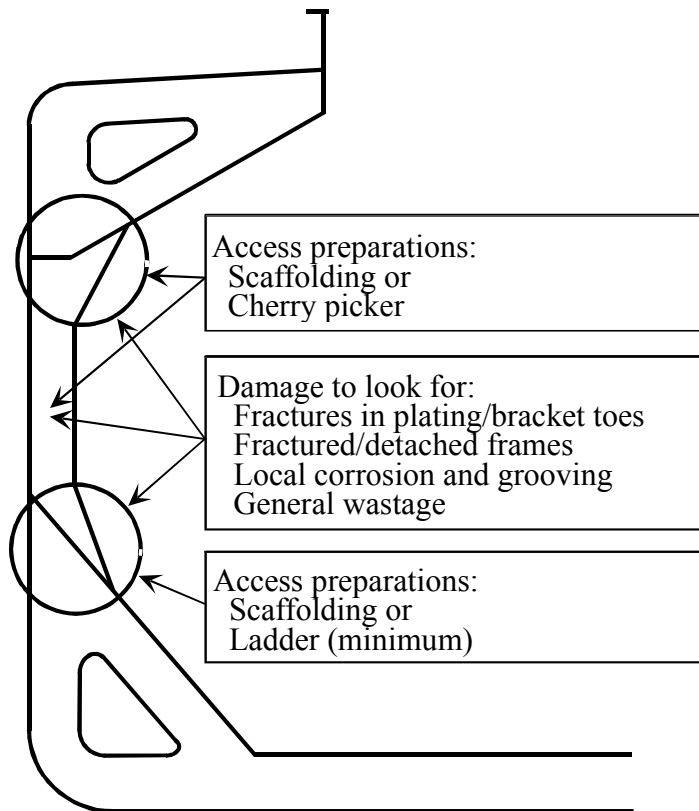


Figure 1
Side shell frame - Potential problem areas

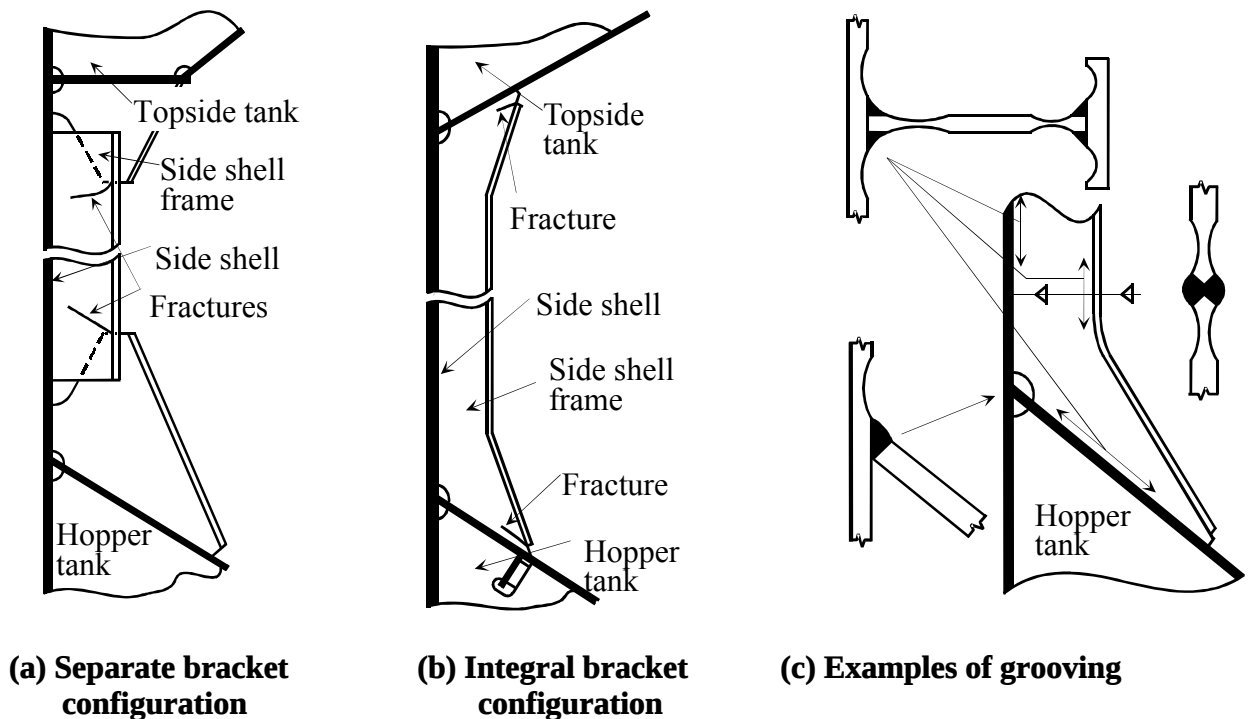


Figure 2 Damages to side shell frame - Potential problem areas

(Note) The type of bracket configuration used will, to a large extent, dictate the location and extent of fracture. Where separate brackets are employed, the fracture location is normally at the bracket toe position on the frames, whereas with integral brackets the location is at the toe position on the hopper and topside tank.

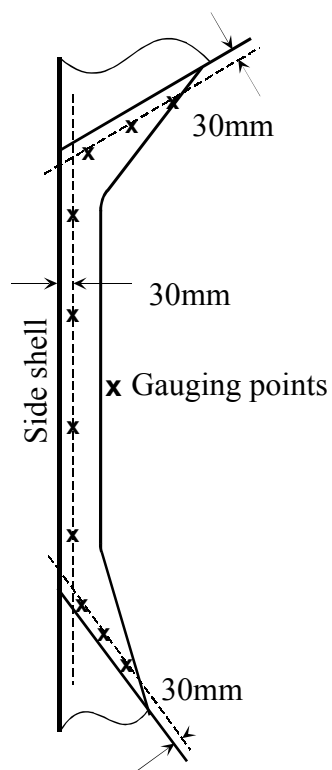


Figure 3
Representative gauging locations on the side shell frame - Potential problem areas

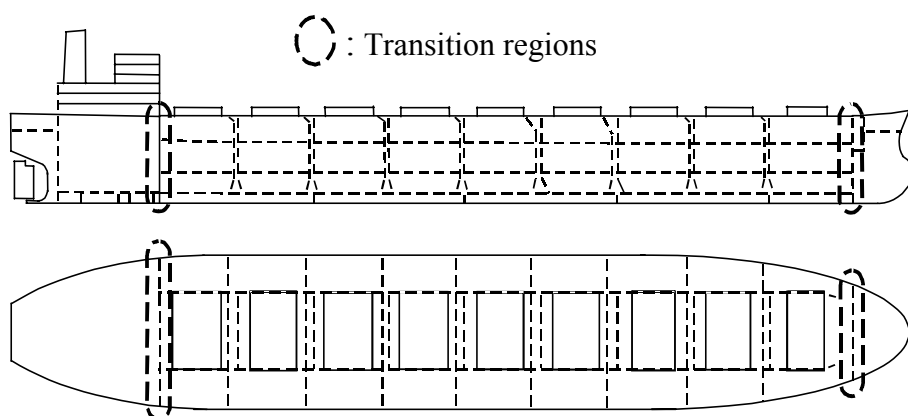


Figure 4 **Transition regions - Potential problem area**



Photograph 1 Collapsed side shell frames (See Example 4)



Photograph 2 Missing side shell structure (See Examples 4 and 5)

2 What to look for - Internal inspection

2.1 Material wastage

- 2.1.1** Attention is drawn to the fact that side shell frames may be significantly weakened by loss of thickness although diminution and deformations may not be apparent. Inspection should be made after the removal of any scale or rust deposit. Thickness measurements may be necessary, particularly if the corrosion is smooth and uniform, to determine the condition of the structure (See **Figure 5**).

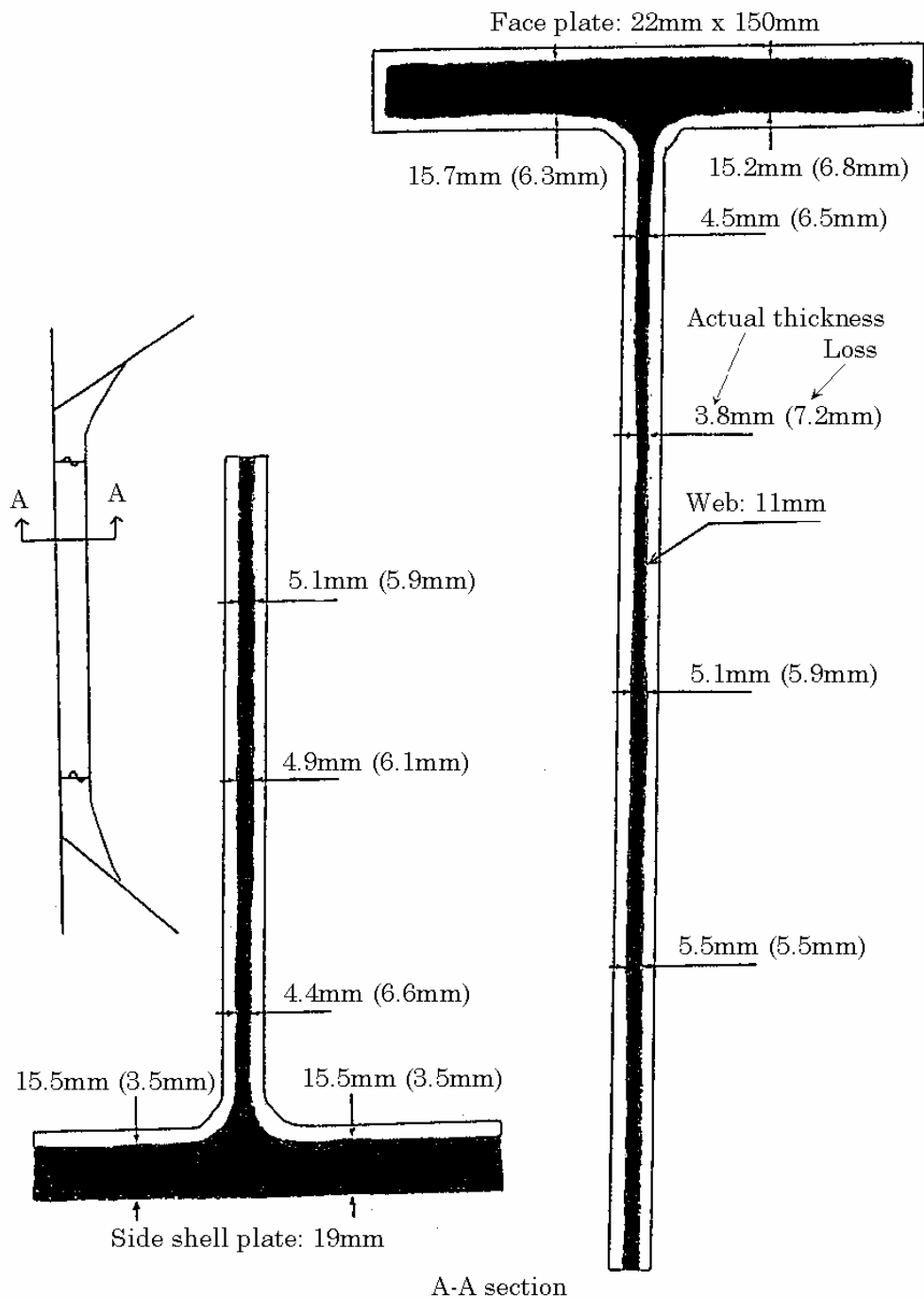


Figure 5 Uniform corrosion of side shell frame

2.1.2 It is not unusual to find highly localised corrosion on uncoated side shell frames and their end connections. The loss in the thickness is normally greater close to the side shell plating rather than near the faceplate, and consequently representative thickness measurements should be in that area (See **Figure 3**). This situation, if not remedied, can result in loss of support to the shell plating and hence large inboard deflections. In many cases such deflections of the side shell plating can generate fractures in the shell plating and fracturing and buckling of the frame web plates and eventually result in detachment of the end brackets from the hopper tank.

2.1.3 Heavy wastage and possible grooving of the framing in the forward/aft hold, where side

shell plating is oblique to frames, may result in fracture and buckling of the shell plating as shown in **Example 5**.

2.1.4 Pitting corrosion may be found under coating blisters which need to be removed before inspection.

It should be noted that the middle part of a frame may be wasted even if the upper and / or lower parts of the frame are not.

The following should be considered (and may be included as a surveyor's checklist):

- Hold Frame scantling drawings for each hold and allowable diminution level
- Repair history of Hold Frames
- Previous thickness measurement reports.
- Diminution of Hold Frames would normally be equal or greater than that of transverse cargo hold bulkheads.
- Note history of cargoes carried, especially that of coal or similar corrosive cargo.
- Record of any coating previously applied.
- Safe means of survey access (staging / cherry picker / portable ladder etc.)

Visual examination should take account of the following:

- The diminution of the face plate can be an indication of diminution level on the webs.
- Thickness of the Web may be estimated from edge condition of scallops.
- Fillet welding between Web and Shell plate and heat affected zone
- Fillet welding between Web and Face plate and heat affected zone
- Fillet welding between Upper Bracket and Top side tank, between Lower Bracket and Bilge Hopper Tank and heat affected zone
- Scallop at Upper and Lower part of Web

Experience with Bulk Carriers 100,000 dwt and above has shown that side shell frames in No.3 hold are more susceptible to damages. Therefore it is recommended that side shell frames in this hold are specially considered.

2.2 Deformations

2.2.1 It is normally to be expected that the lower region of the frames will receive some level of damage during operational procedures, e.g. when unloading with the aid of grabs and bulldozers or during loading of logs. This can range from damage of the side frame end bracket face plates to large physical deformations of a number of frames and in some cases can initiate fractures.

These individual frames and frame brackets, if rendered ineffective, will place additional load on the adjacent frames and failure by the “domino effect” can in many cases extend over the side shell of a complete hold.

2.3 Fractures

2.3.1 Fractures are more evident at the toes of the upper and lower bracket(s) or at the connections between brackets and frames. In most cases the fractures may be attributed to stress concentrations and stress variations created, in the main, by loads from the seaway. The stress concentrations can be a result of poor detail design and/or bad workmanship. Localised fatigue fracturing, possibly in association with localised corrosion, may be difficult to detect and it is stressed that the areas in question should receive close attention during periodical surveys.

2.3.2 Fractures are more often found at the boundary structure of a cargo/ballast hold than other cargo holds. This area should be subjected to close-up examination.

2.3.3 Fractures in shell plating and supporting or continuation/extension brackets at collision bulkhead and engine room forward bulkhead are frequently found by close-up examination.

3 What to look for – External inspection

3.1 Material wastage

3.1.1 The general condition with regard to wastage of the ship's sides may be observed by visual inspection from the quay side of the area above the waterline. Special attention should be paid to areas where the painting has deteriorated.

3.2 Deformations

3.2.1 The side shell should be carefully inspected with respect to possible deformations. The side shell below water line can usually only be inspected when the ship is dry docked. Therefore special attention with respect to possible deformations should be paid during dry-docking. When deformation of the shell plating is found, the area should also be inspected internally since even a small deformation may indicate serious damage to the internal structure.

3.2.2 Side shell plating in foremost cargo hold may suffer buckling. Since the shell plating in fore body has curvature in longitudinal direction due to the slenderness, external loads, such as static and dynamic water pressure cause compressive stress in side shell. Therefore the ships of which side shell plating is high tensile steel or has become thin due to corrosion may suffer buckling resulting in fracture along collision bulkhead or side shell frames.

3.3 Fractures

3.3.1 Fractures in the shell plating above and below the water line in way of ballast tanks may be detected during dry-docking as wet area in contrast to otherwise dry shell plating.

4 General comments on repair

4.1 Material wastage

4.1.1 In general, where part of the hold framing and/or associated end brackets have deteriorated to the permissible minimum thickness level, the normal practice is to crop and renew the area affected. However, if the remaining section of the frames/brackets marginally remain within the allowable limit, surveyors should request that affected frames and associated end brackets be renewed. Alignment of end brackets with the structure inside hopper tank or topside tank is to be ensured. It is recommended that repaired areas be coated.

4.1.2 If pitting intensity is lower than 15% in area (see **Figure 6**), pitting greater than $\frac{1}{4}$ of the original thickness can be welded flush with the original surface.
If deep pits are clustered together or remaining thickness is less than 6 mm, the plate should be renewed by plate inserting instead of repairing by welding.

4.2 Deformations

4.2.1 Depending on the extent of the deformation, the structure should be restored to its original shape and position either by fairing in place or by cropping and renewing the affected structure.

4.3 Fractures

4.3.1 Because of the interdependence of structural components it is important that all fractures and other significant damage to the side shell, frames and their end brackets, however localised, are repaired.

4.3.2 Fractured part of supporting brackets and continuation/extension brackets at collision bulkhead, deep tank bulkheads, and engine room bulkhead are to be part renewed with consideration given to the modification of the shape and possible extension of the brackets to reduce stress concentration. Affected shell plating in way of the damaged brackets should be cropped and renewed.

4.3.3 Repair of fractures at the boundary of a cargo hold should be carefully considered, taking into account necessary structural modification, enhanced scantlings and material, to prevent recurrence of the fractures.

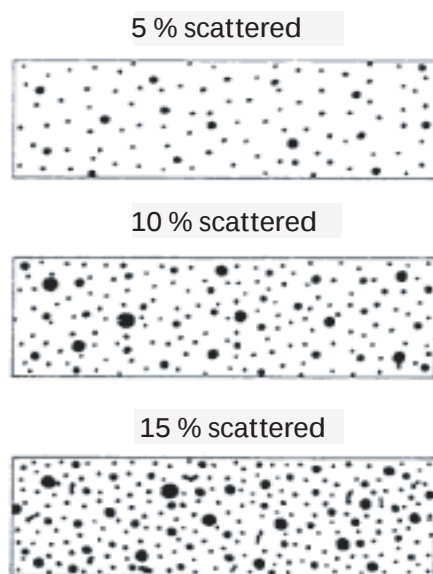
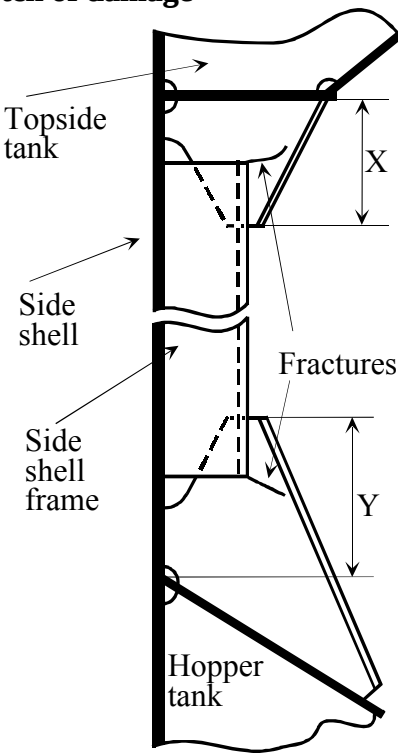
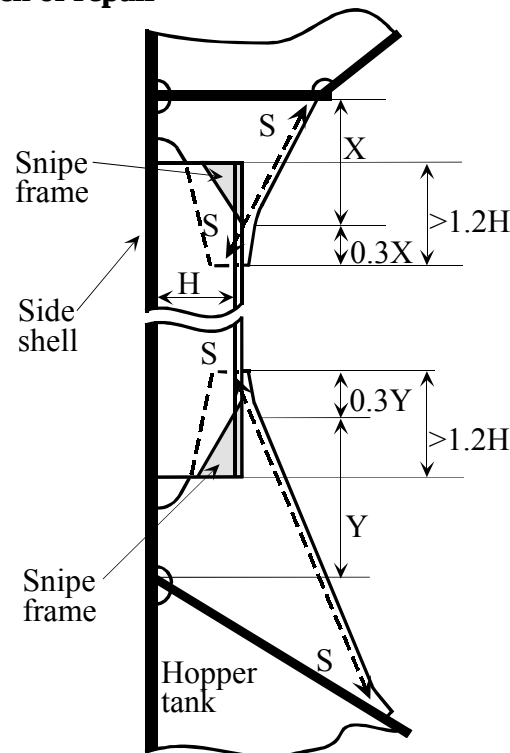
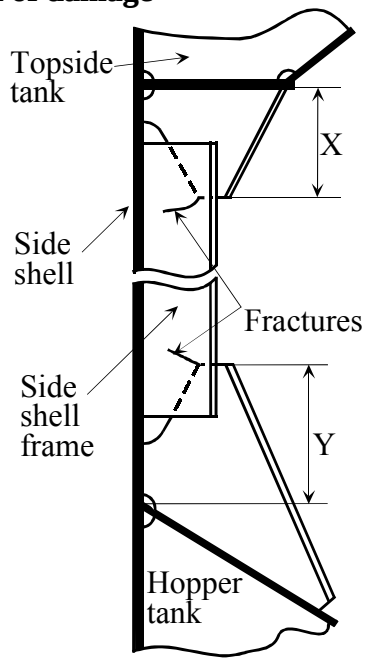
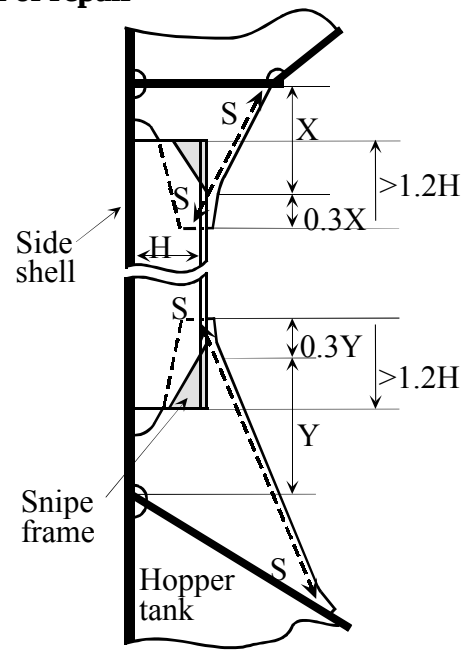
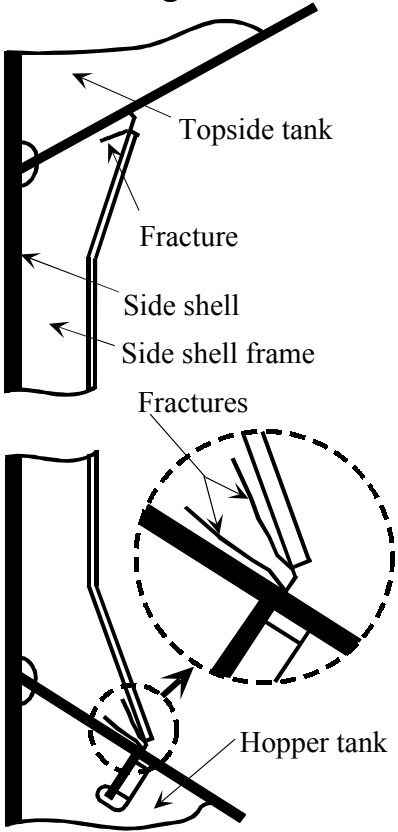
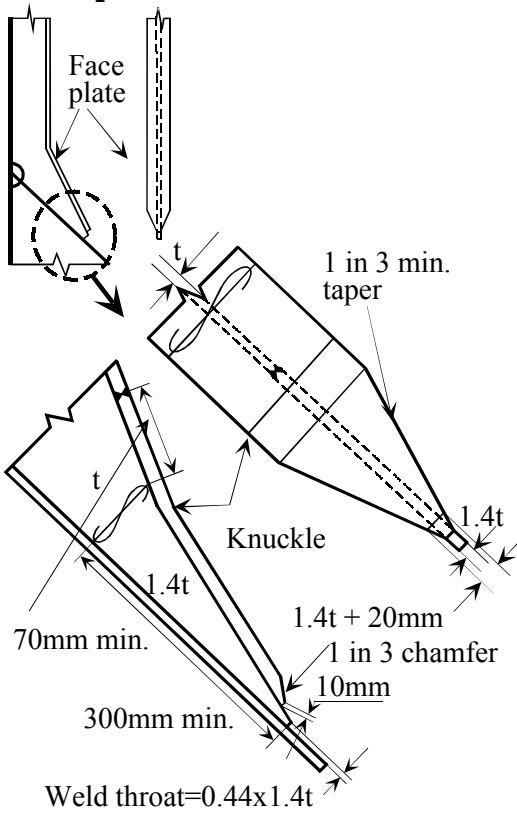
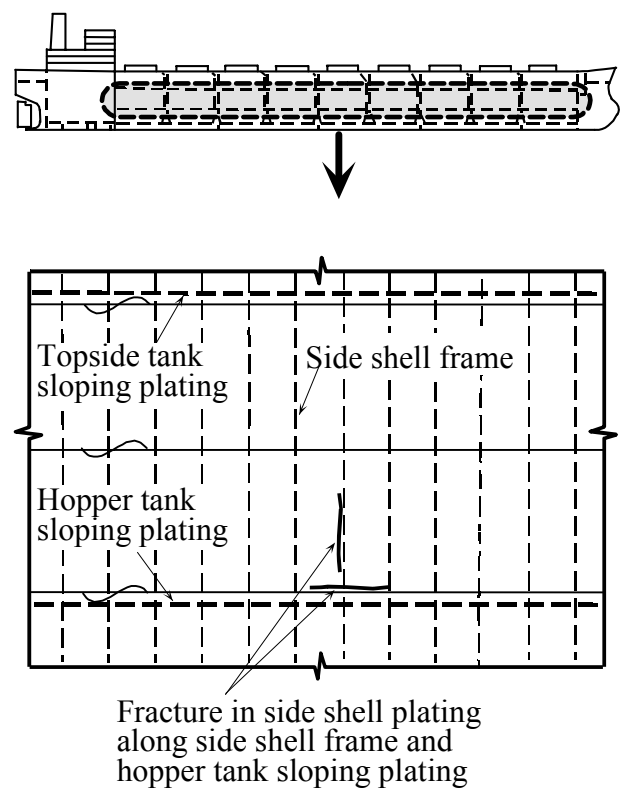
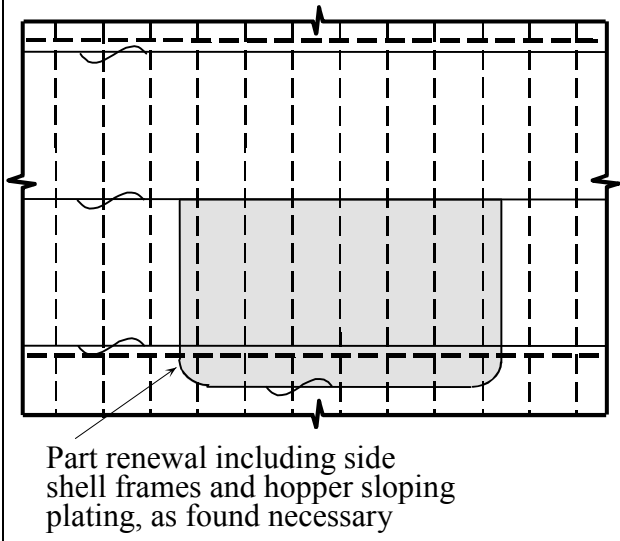


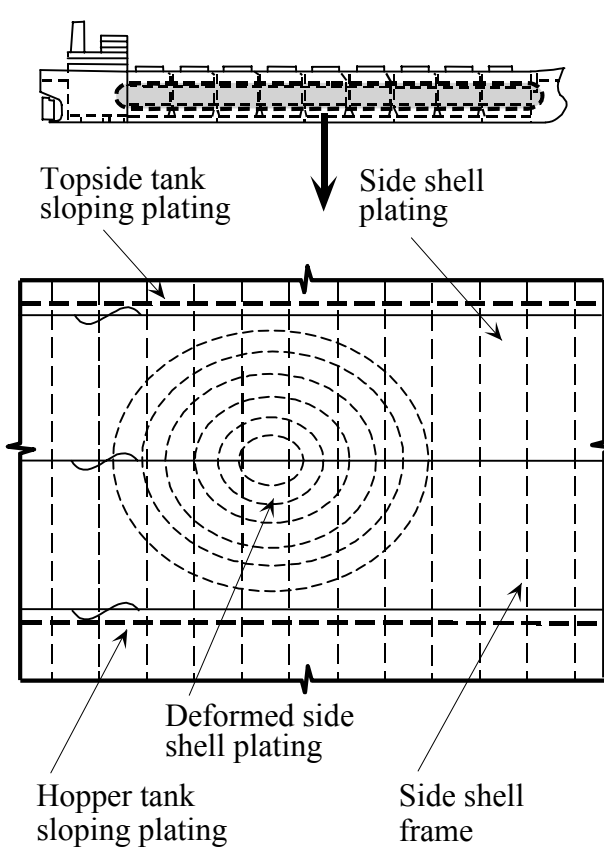
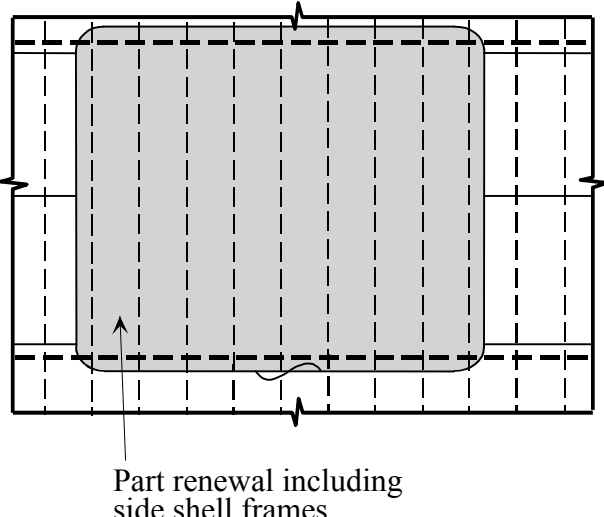
Figure 6 Pitting intensity diagrams (from 5% to 15% intensity)

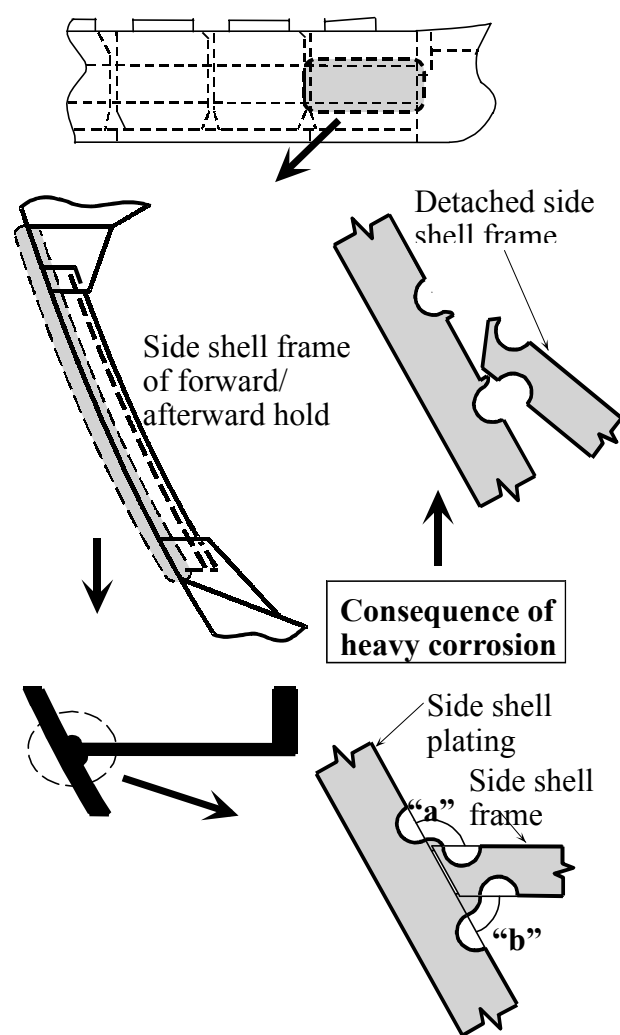
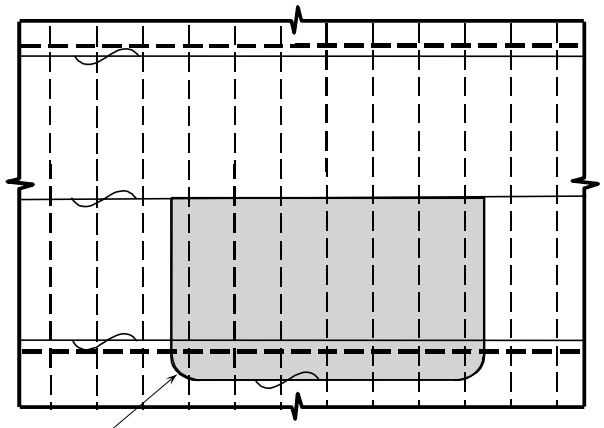
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure
Part 1	Cargo hold region	Example No. 1-a
Area 3	Cargo hold side structure	
Detail of damage		Fractures in brackets at termination of frame
Sketch of damage  Separate bracket configuration		Sketch of repair  S=Snipped end
Notes on possible cause of damage 1. This type of damage is caused due to stress concentration.		Notes on repairs 1. For small fractures, e. g. hairline fractures, the fracture can be veed-out, ground, examined by NDT for fractures, and rewelded. 2. For larger/significant fractures consideration is to be given to cropping and partly renewing/renewing the frame brackets. If renewing the brackets, end of frames can be sniped to soften them. 3. If felt prudent, soft toes are to be incorporated at the boundaries of the bracket to the hopper plating. 4. Attention to be given to the structure in wing tanks in way of the extended bracket arm. i.e. reinforcement provided in line with the bracket.

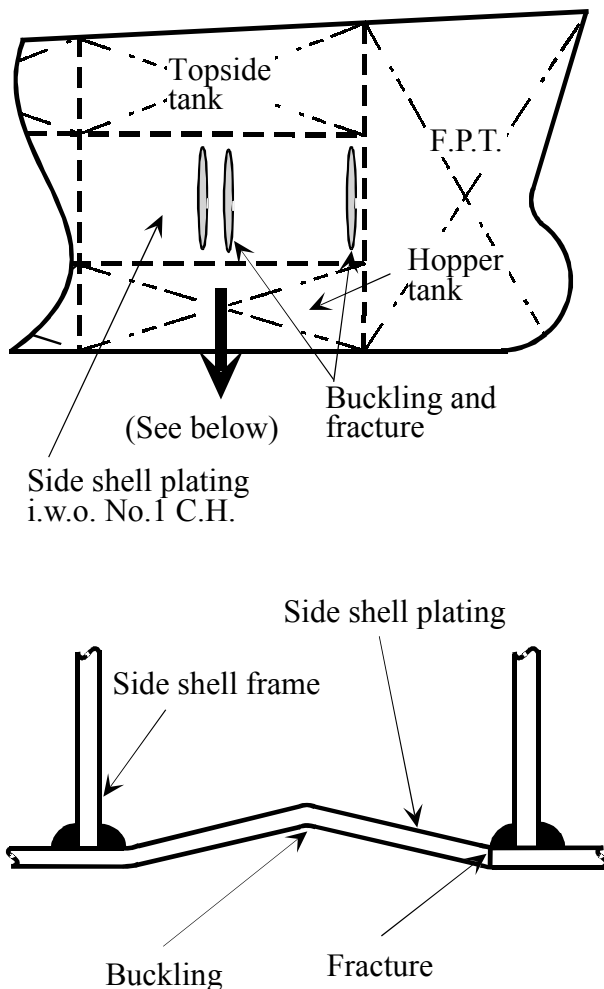
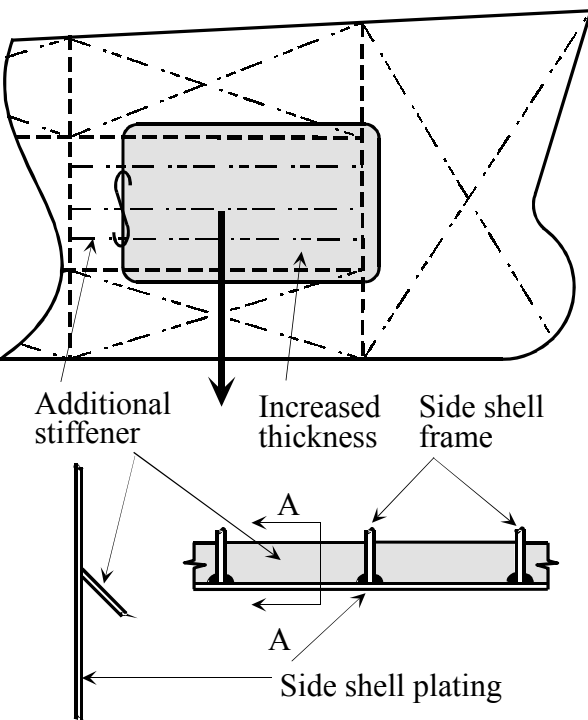
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No. 1-b	
Area 3	Cargo hold side structure		
Detail of damage		Fractures in side shell frame at bracket's toe	
Sketch of damage  Separate bracket configuration		Sketch of repair  S=Snipped end	
Notes on possible cause of damage 1. This type of damage is caused due to stress concentration.		Notes on repairs 1. For small fractures, e. g. hairline fractures, the fracture can be veed-out, welded up, ground, examined by NDT for fractures, and rewelded. 2. For larger/significant fractures consideration is to be given to cropping and partly renewing/ renewing the frame brackets. If renewing the brackets, end of frames can be sniped to soften them. 3. If felt prudent, soft toes are to be incorporated at the boundaries of the bracket to the hopper plating. 4. Attention to be given to the structure in wing tanks in way of the extended bracket arm. i.e. reinforcement provided in line with the bracket.	

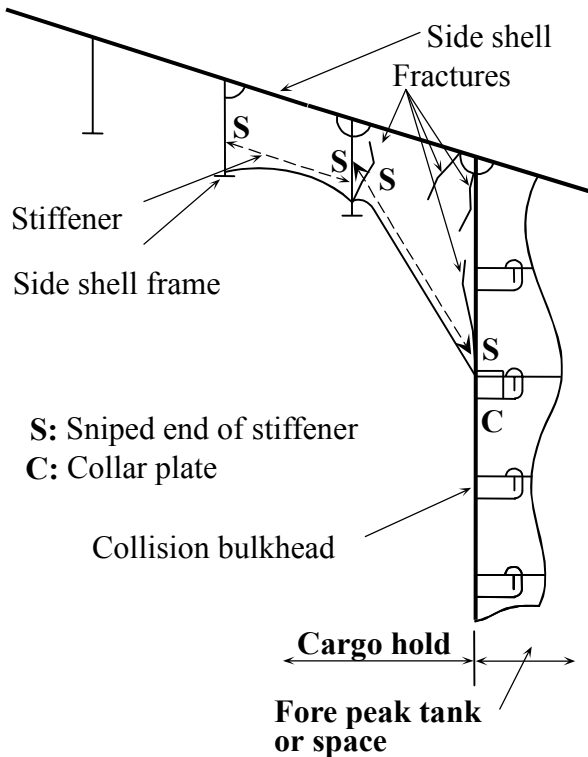
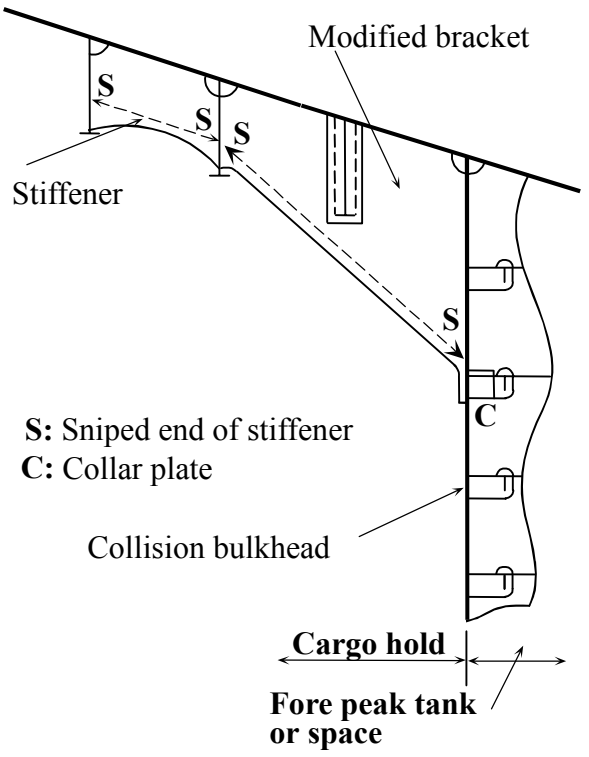
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 3	Cargo hold side structure		2
Detail of damage		Fractures in side shell frame at bracket's toe	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. This type of damage is caused due to stress concentration.		Notes on repairs 1. Repair is to incorporate a design similar to the one shown on the sketch and in addition:- 1.1. The arm of the bracket along the hopper/ topside plating should be increased by altering the angle of the bracket face plate. A face plate taper of 1 in 3 should be arranged. 1.2. The local thickness of the bracket web plating over the length of the new face plate taper should be increased by about 40% above that originally fitted. 1.3. The face plate thickness should be chamfered 1 in 3 to a thickness at its extremity. 1.4. Welding of the new bracket toe should be based on a weld factor of 0.44 applied to the increased thickness. 2. Attention to be given to the structure in wing tanks in way of the extended bracket arm, i.e. reinforcement provided in line with the bracket.	

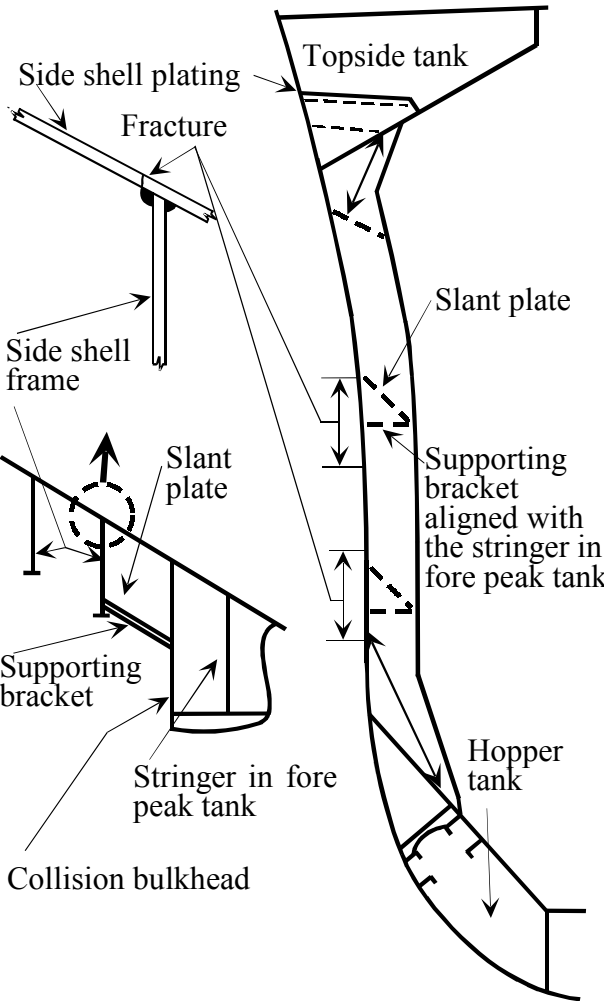
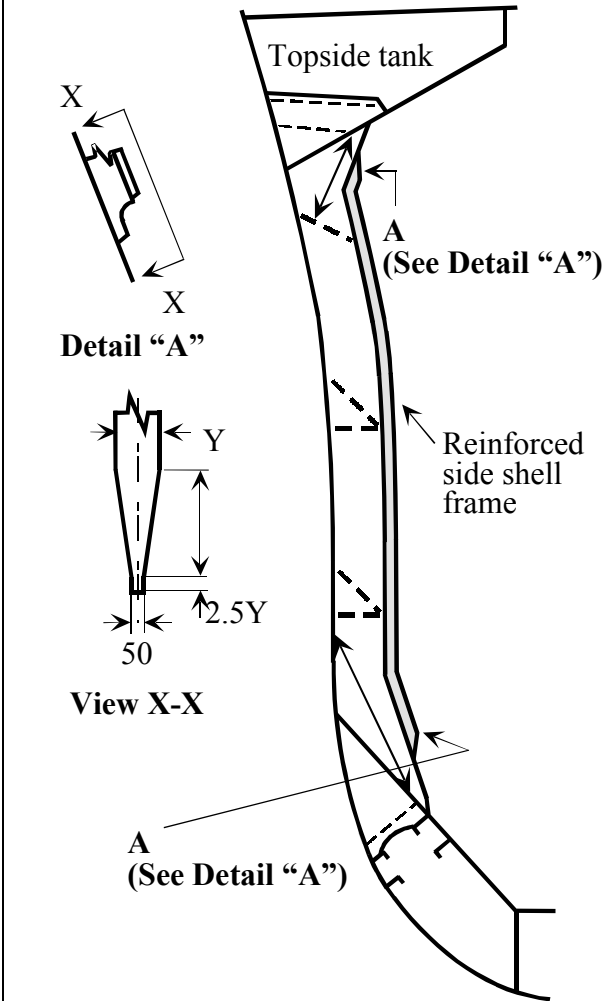
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 3	Cargo hold side structure	3	
Detail of damage		Fractures in side shell frame/lower bracket and side shell plating near hopper	
Sketch of damage  Topside tank sloping plating Side shell frame Hopper tank sloping plating Fracture in side shell plating along side shell frame and hopper tank sloping plating		Sketch of repair  Part renewal including side shell frames and hopper sloping plating, as found necessary	
Notes on possible cause of damage 1. Heavy corrosion (grooving). Refer to Figure 2 (c) .		Notes on repairs 1. Sketch of repair applies when damage extends over several frames. 2. Isolated fractures may be repaired by veeing-out and rewelding. 3. Isolated cases of grooving may be repaired by build up of welding.	

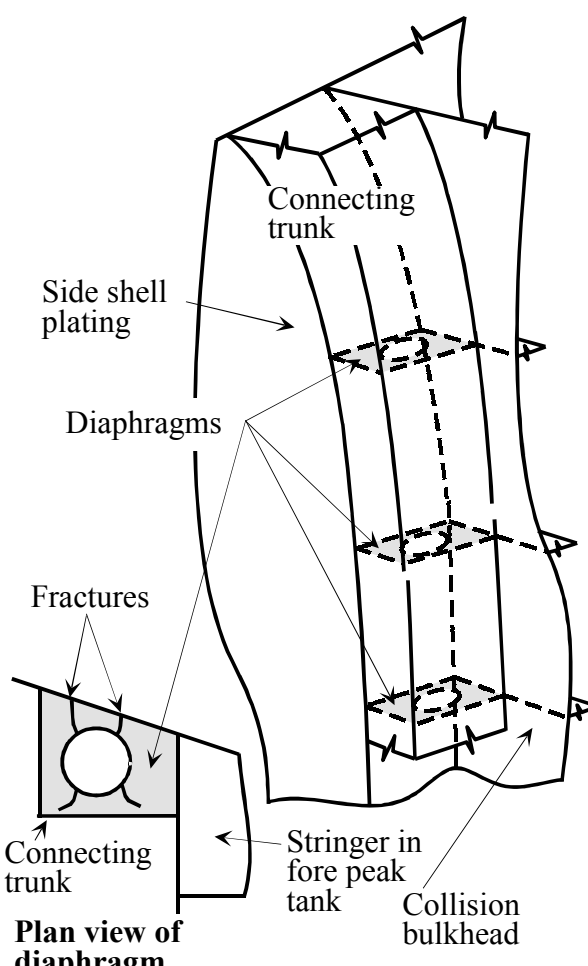
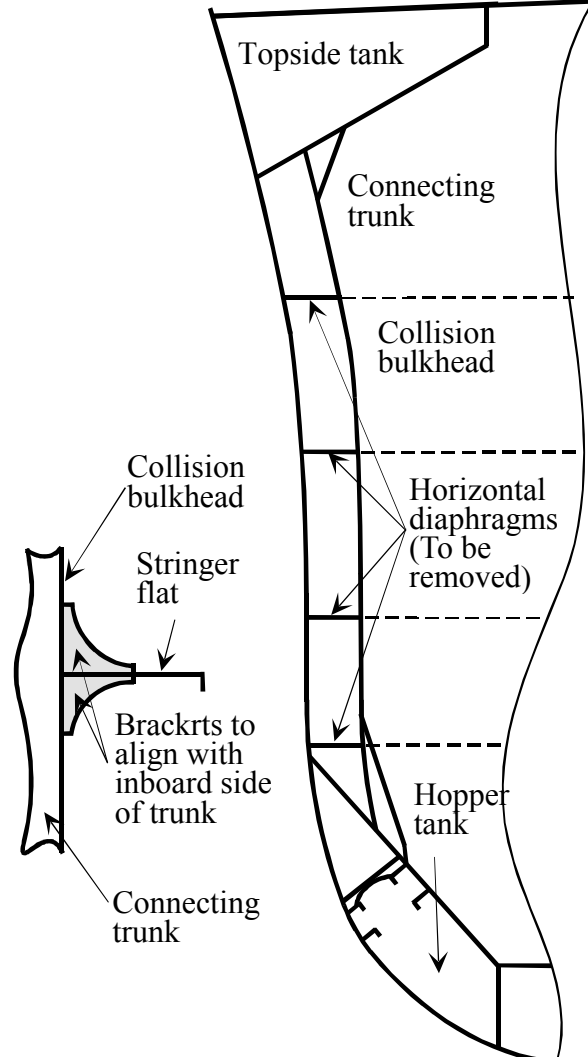
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 3	Cargo hold side structure	4	
Detail of damage		Deformation of side shell plating	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Insufficient stiffness of side shell frames due to buckling and/or detachment of side shell frames due to corrosion. 2. Heavy weather.		Notes on repairs 1. Deformed side shell plating including side shell frames should be cropped and renewed.	

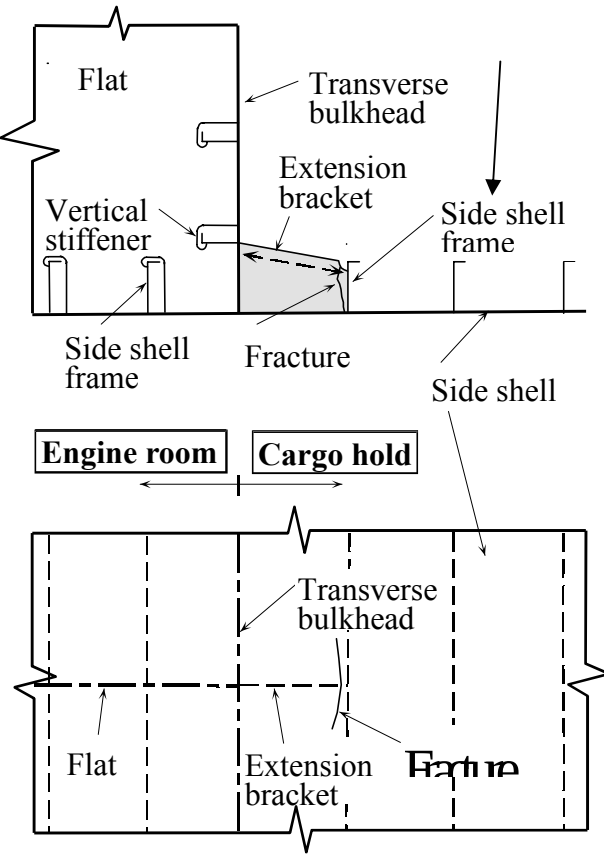
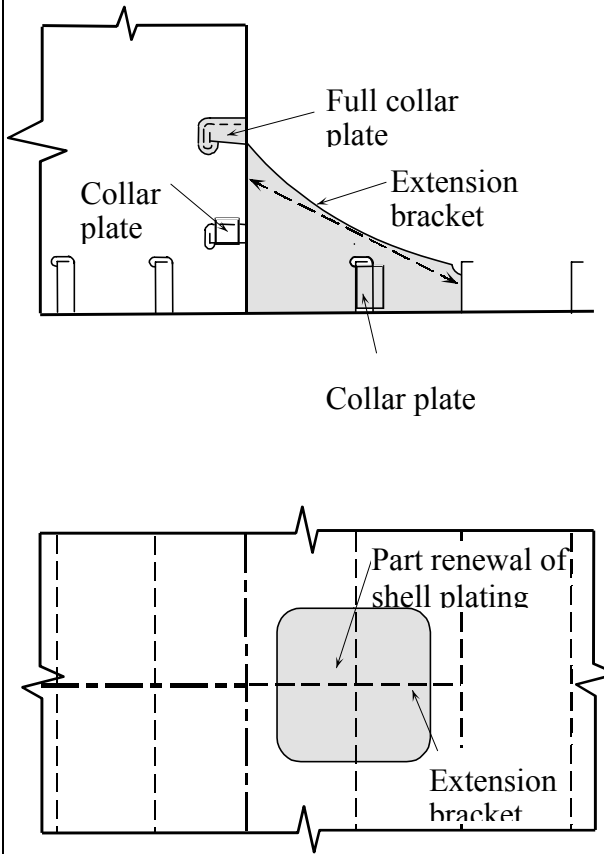
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 3	Cargo hold side structure	5	
Detail of damage		Adverse effect of corrosion on the frame of forward/afterward hold	
Sketch of damage 		Sketch of repair  1. Part renewal including side shell frames and hopper plating, as found necessary 2. Deep penetration welding at the connections of side shell frames to side shell plating	
Notes on possible cause of damage 1. Heavy corrosion (grooving) of side shell frame along side shell plating and difference of throat thickness "a" from "b". (Since original throat thickness of "a" is usually smaller than that of "b", if same welding procedure is applied, the same corrosion has a more severe effect on "a", and may cause collapse and/or detachment of side shell frame.)		Notes on repairs 1. Sketch of repair applies when damage extends over several frames. 2. Isolated fractures may be repaired by veeing-out and rewelding. 3. Isolated cases of grooving may be repaired by build up of welding.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 3	Cargo hold side structure	6	
Detail of damage		Buckling and fractures of side shell plating in foremost cargo hold	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Heavy weather. 2. Insufficient buckling strength due to high tensile steel or heavy uniform corrosion. 3. Inadequate transition structure.		Notes on repairs 1. Buckled/fractured side shell plating is to be cropped and renewed. 2. Reinforcement by thicker side shell plating and/or additional stiffeners should be considered.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 3	Cargo hold side structure	7	
Detail of damage		Fractures at the supporting brackets in way of the collision bulkhead	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Insufficient bracket size resulting in high stress due to load cantilevered from side frame. 2. Stress concentration at toe of bracket and misalignment between bracket and stringer in fore peak tank or space.		Notes on repairs 1. The extended bracket arm connection to the collision bulkhead is to have a soft toe, and any cut-outs for stiffeners in the fore peak tank or space are to be collared when situated in the vicinity of the bracket toe. 2. When fractures have extended into the side shell or bulkhead plating, the plating is to be cropped and part renewed.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 3	Cargo hold side structure	8	
Detail of damage		Fractures at the supporting brackets in way of the collision bulkhead with no side shell panting stringer in hold	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Damage caused by stress concentration leading to fatigue fracture in side shell. This has been exacerbated because of the greater flexibility of the hold structure in relation to the structure forward of the collision bulkhead.		Notes on repairs 1. Fractured shell plates to be cropped and part renewed, and side shell frame/frames in the vicinity of the damage to be reinforced as required by the CCS.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 3	Cargo hold side structure	9	
Detail of damage		Fractures in way of horizontal diaphragm in the connecting trunk between topside tank and hopper double bottom tank, on after side of collision bulkhead	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
Damage caused by stress concentration resulting from the discontinuity created by the trunk and diaphragm structure. This has been exacerbated because of the greater flexibility of the hold structure in relation to the trunk and structure forward of the collision bulkhead.		Diaphragm to be removed permanently and fractured shell plated cropped and part renewed, or veed and weld as necessary in way of damage. Brackets with softened toes are to be fitted on forward side of collision bulkhead in way of stringers/flats to align with inboard side of trunk in order to remove hard-spots.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure
Part 1	Cargo hold region	Example No.
Area 3	Cargo hold side structure	10
Detail of damage		Fractures in way of continuation/extension brackets in aftermost hold at the engine room bulkhead
Sketch of damage		Sketch of repair
		
Notes on possible cause of damage		Notes on repairs
1. Damage caused by stress concentration leading to fatigue fracture on side shell. This will be exacerbated because of the greater flexibility of the hold structure in relation to the engine room structure.		1. The fractured shell plating is to be cropped and part renewed as necessary. 2. Extension bracket is to be modified and collar plates to cut-outs in engine room flat are to be installed.

Area 4 Transverse bulkhead including stool structure

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1 General

2 What to look for - Hold inspection

- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 What to look for - Stool inspection

- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

4 General comments on repair

- 4.1 Material wastage
- 4.2 Deformations
- 4.3 Fractures

Figures and/or Photographs - Area 4	
No.	Title
Figure 1	Transverse bulkhead - Potential problems areas
Figure 2	Typical fracturing at the connection of transverse bulkhead structure
Photograph 1	Collapsed and detached transverse bulkhead

Examples of structural detail failures and repairs - Area 4	
Example No.	Title
1-a	Fractures at weld connections to stool shelf plate
1-b	Fractures at weld connections to stool shelf plate
2	Fractures at the upper boundaries to topside tank
3	Indentation and buckling of vertical corrugations
4	Fractures in the web of the corrugation initiating at intersection of adjacent shedder plates
5	Fractures at welded connections of lower stool plating to inner bottom plating in way of duct keel
6	Fractures at connection of lower stool to hopper
7	Buckling of strut supporting hatch end beam

1 General

- 1.1** The transverse bulkheads at the ends of dry cargo holds are mainly ordinary watertight bulkheads serving two main functions:
- (a) As main transverse strength elements in the structural design of the ship.
 - (b) As subdivision to prevent progressive flooding in an emergency situation.
- 1.2** The transverse bulkheads at the ends of a combined ballast/ cargo hold are deep tank bulkheads which, in addition to the functions given in 1.1, are designed to withstand the water pressure from a hold fully filled with water ballast.
- 1.3** The bulkheads are commonly constructed as vertically corrugated with a lower stool, and with or without an upper stool (See **Chapter 3 Technical background for surveys - Figure 3 (b)**). Other constructions may be:
Plane bulkhead plating with one sided vertical stiffeners.
Double plated bulkhead with internal stiffening, with or without stool(s).
- 1.4** Dry cargo holds, not designed as ballast holds, may sometimes be partially filled with water ballast in order to achieve a satisfactory air draught at the loading/discharging berths.
The filling is restricted to a level that corresponds to the dry cargo hold scantlings, in particular the transverse bulkheads scantlings, and must only be carried out in port. In no case should these cargo holds be partially filled during voyage to save time at the berth. Such filling at sea may cause sloshing resulting in catastrophic failure such as indicated in **Photograph 1**.
- 1.5** Heavy corrosion may lead to collapse of the structure under extreme load, such as indicated in **Photograph 1** if it is not rectified properly.
- 1.6** A summary of potential problem areas is shown in **Figure 1**. It is emphasised that appropriate access arrangement as indicated in **Chapter 4 Survey planning, preparation and execution** of the guidelines, should be provided to enable a proper close-up inspection and thickness measurement as necessary.



Photograph 1
Collapsed and detached
transverse bulkhead

Collapsed and detached transverse bulkhead on the tank top

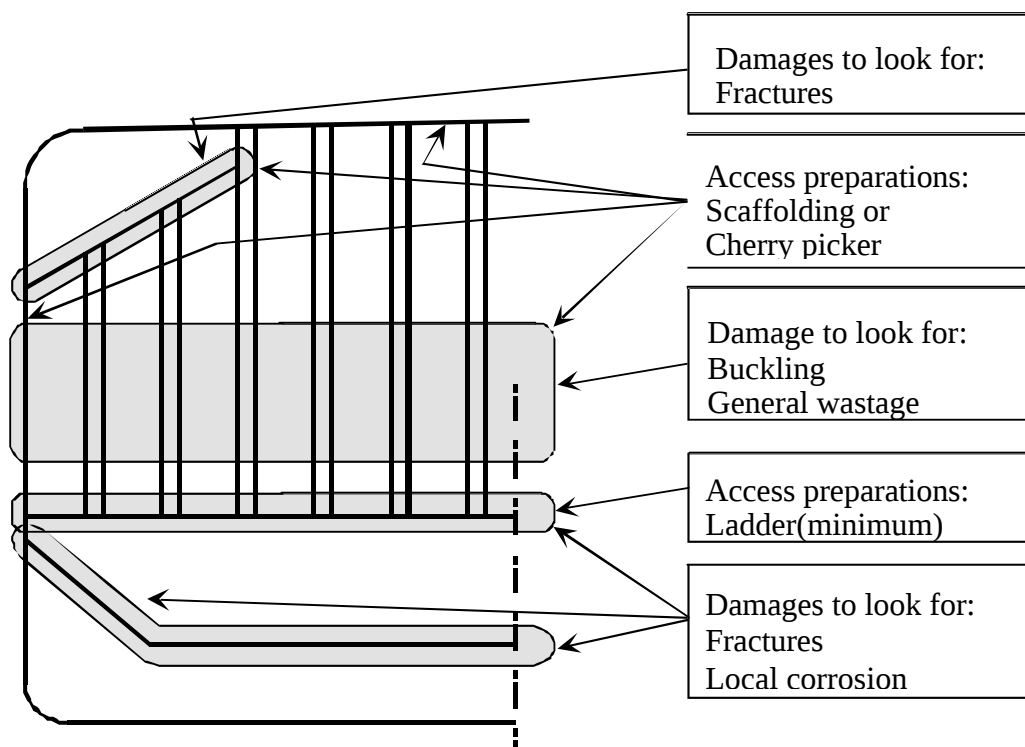


Figure 1 **Transverse bulkhead - Potential problem areas**

2 What to look for - Hold inspection

2.1 Material wastage

2.1.1 Excessive corrosion may be found in the following locations.

- (a) At the mid-height and at the bottom of the bulkheads. The structure may look in deceptively good condition but in fact may be heavily corroded. The corrosion is created by the corrosive effect of cargo and environment, in particular when the structure is not coated.
- (b) Bulkhead plating adjacent to the shell plating
- (c) Bulkhead trunks which form part of the venting, filling and discharging arrangements between the topside tanks and the hopper tanks.
- (d) Bulkhead plating and weld connections to the lower/upper stool shelf plates and inner bottom.
- (e) In way of weld connections to topside tanks and hopper tanks.

2.1.2 If coatings have broken down and there is evidence of corrosion, it is recommended that random thickness measurements be taken to establish the level of diminution.

2.1.3 Where the terms and requirements of the periodical survey dictate thickness measurement, or when the surveyor deems necessary, it is important that the extent of the gauging be sufficient to determine the general condition of the structure.

2.2 Deformations

2.2.1 Deformation due to mechanical damage is often found in bulkhead structure.

2.2.2 When the bulkhead has sustained serious uniform corrosion, the bulkhead may suffer shear buckling. Evidence of buckling may be indicated by the peeling of paint or rust. However, where deformation resulting from bending or shear buckling has occurred on a bulkhead with a small diminution in thickness, this could be due to poor design or overloading and this aspect should be investigated before proceeding with repairs.

2.3 Fractures

2.3.1 Fractures usually occur at the boundaries of corrugations and bulkhead stools particularly in way of shelf plates, shedder plates, deck, inner bottom, etc. (See **Figure 2**).

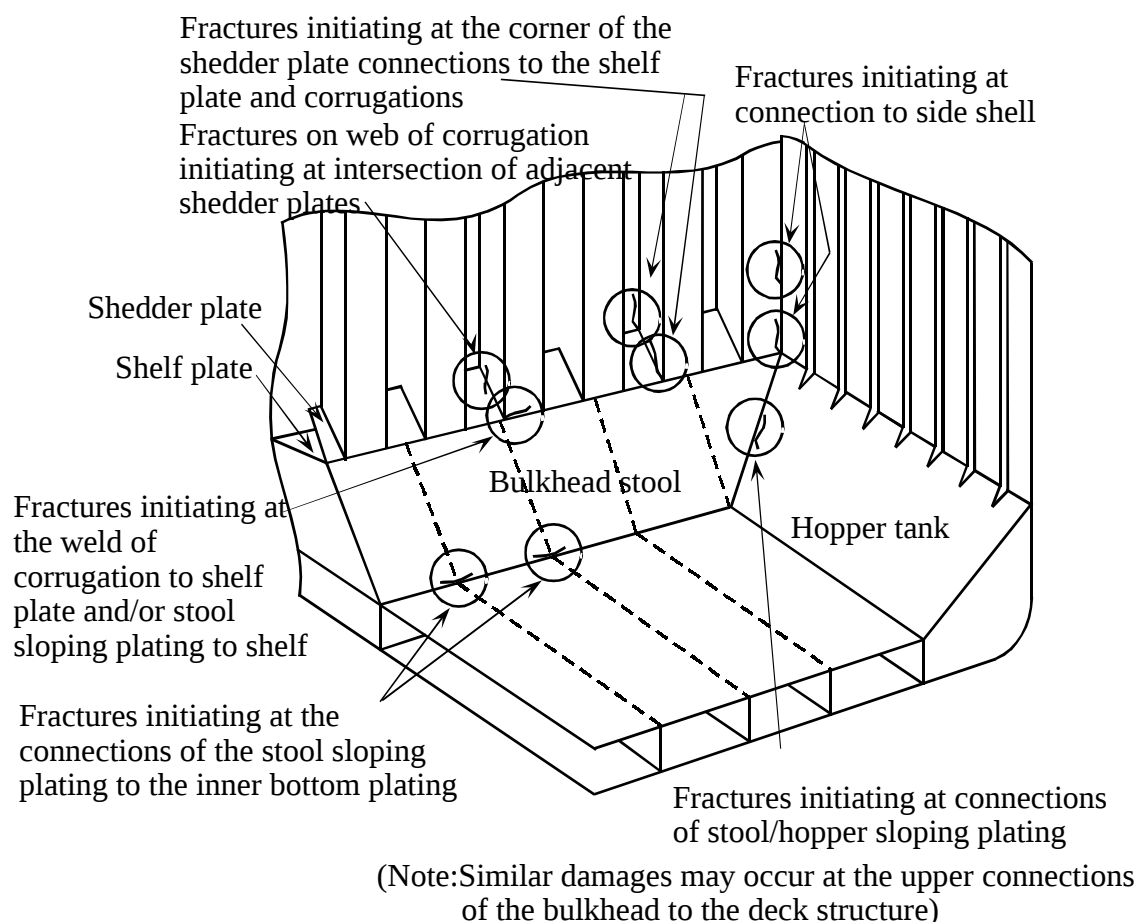


Figure 2 Typical fracturing at the connection of transverse bulkhead structure

3 What to look for - Stool inspection

3.1 Material wastage

3.1.1 Excessive corrosion may be found on diaphragms, particularly at their upper and lower weld connections.

3.2 Deformations

3.2.1 Damage to the stool structure should be checked when deformation due to mechanical damage is observed during hold inspection.

3.3 Fractures

3.3.1 Fractures observed at the connection between lower stool and corrugated bulkhead during hold inspection may have initiated at the weld connection of the inside diaphragms (See **Example 1**).

3.3.2 Misalignment between bulkhead corrugation flange and sloping stool plating may also cause fractures at the weld connection of the inside diaphragms (See **Example 2**).

4 General comments on repair

4.1 Material wastage

4.1.1 When the reduction in thickness of plating and stiffeners has reached the diminution levels permitted by the CCS involved, the wasted plating and stiffeners are to be cropped and renewed.

4.2 Deformations

4.2.1 If the deformation is local and of a limited extent, it could generally be faired out. Deformed plating in association with a generalized reduction in thickness should be partly or completely renewed.

4.2.2 Buckling of the bulkhead plating can also occur in way of the side shell resulting from contact damage and this is usually quite obvious. In such cases the damaged area is to be cropped and partly renewed. If the deformation is extensive, replacement of the plating, partly or completely, may be necessary. If the deformation is not in association with generalized reduction in thickness or due to excessive loading, additional strengthening should be considered.

4.3 Fractures

4.3.1 Fractures that occur at the boundary weld connections as a result of latent weld defects should be veed-out, appropriately prepared and re-welded preferably using low hydrogen electrodes or equivalent.

4.3.2 For fractures other than those described in **4.3.1**, re-welding may not be a permanent solution and an attempt should be made to improve the design and construction in order to obviate a recurrence. Typical examples of such cases are as follows:

(a) **Fractures in the weld connections of the stool plating to the shelf plate in way of the scallops in the stool's internal structure**

The scallops should be closed by fitting over-lap collar plates and the stool weld connections repaired as indicated in **4.3.1**. The over-lap collar should have a full penetration weld connection to the stool and shelf plate and should be completed using low hydrogen electrodes prior to welding the collar to the stool diaphragm/bracket.

(b) **Fractures in the weld connections of the corrugations and/or stool plate to the shelf plate resulting from misalignment of the stool plate and the flange of the corrugation (Similarly misalignment of the stool plate with the double bottom floor)**

It is recommended that the structure be released, the misalignment rectified, and the stool, floor and corrugation weld connection appropriately repaired as indicated in **4.3.1**. Other remedies to such damages include fitting of brackets in the stool in line with the webs of the corrugations. In such cases both the webs of the corrugations and the brackets underneath are to have full penetration welds and the brackets are to be arranged without scallops. However, in many cases this may prove difficult to attain.

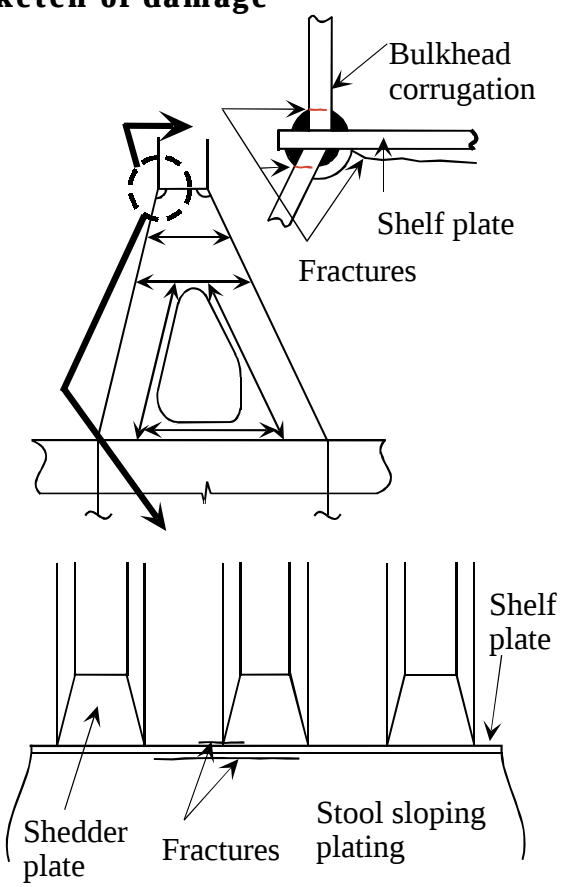
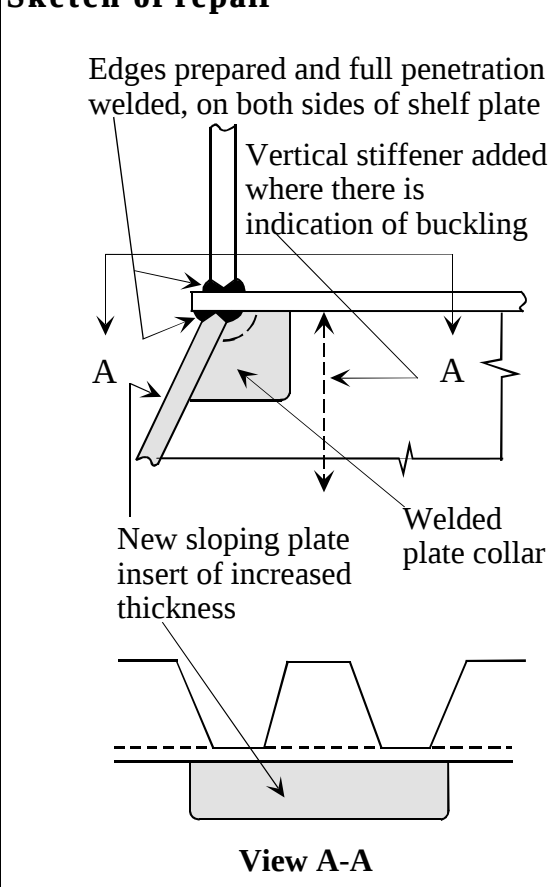
(c) **Fractures in the weld connections of the corrugation to the**

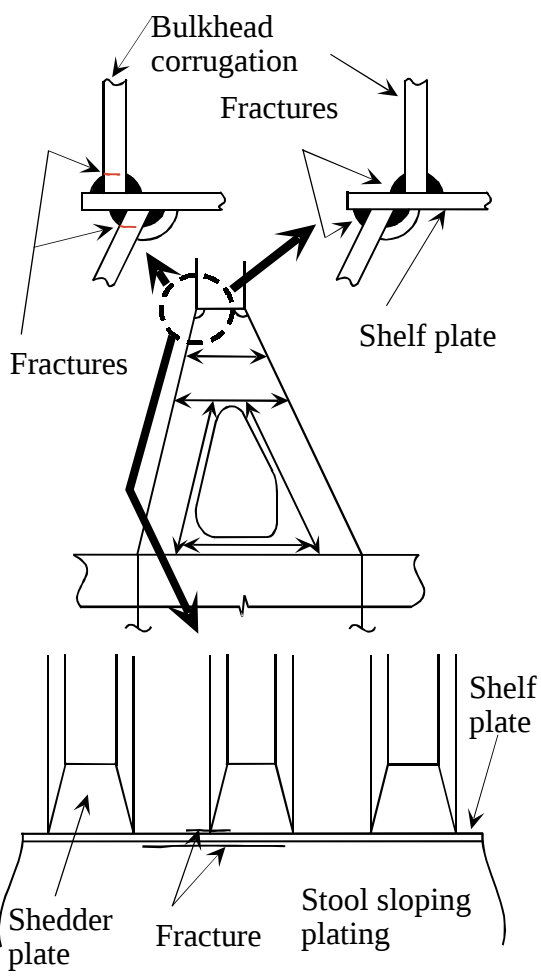
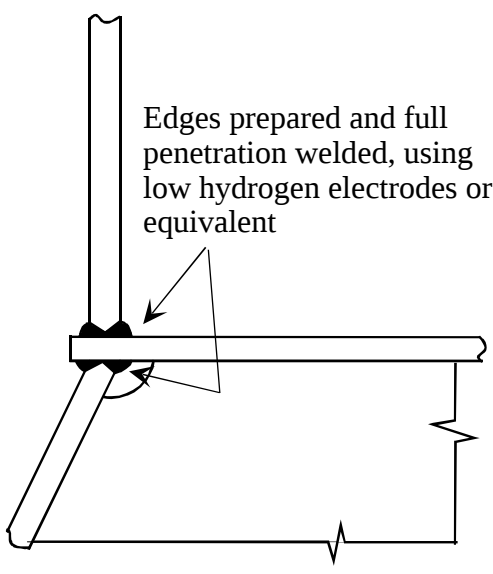
lower shelf plate resulting from fractured welding of the adjacent shedder plate

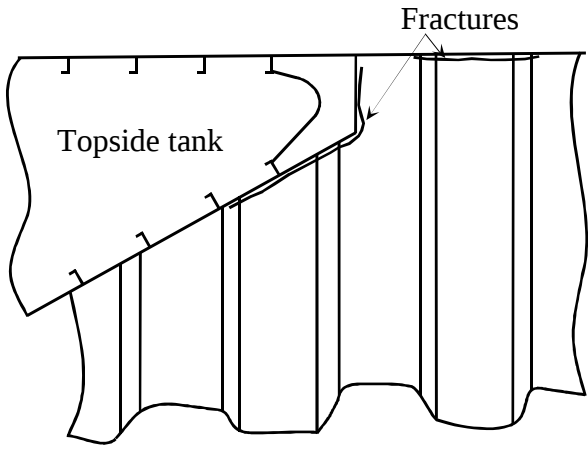
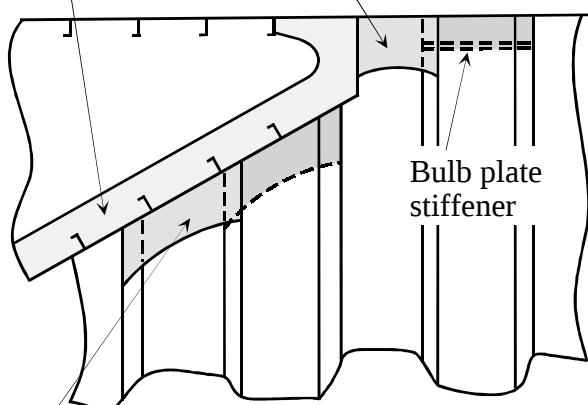
It is recommended that suitable scallops be arranged in the shedder plate in way of the connection, and the weld connections of the corrugations be repaired as indicated in **4.3.1**.

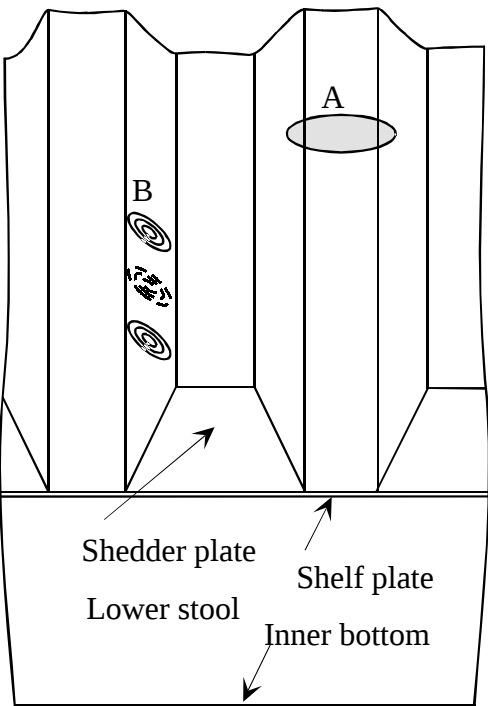
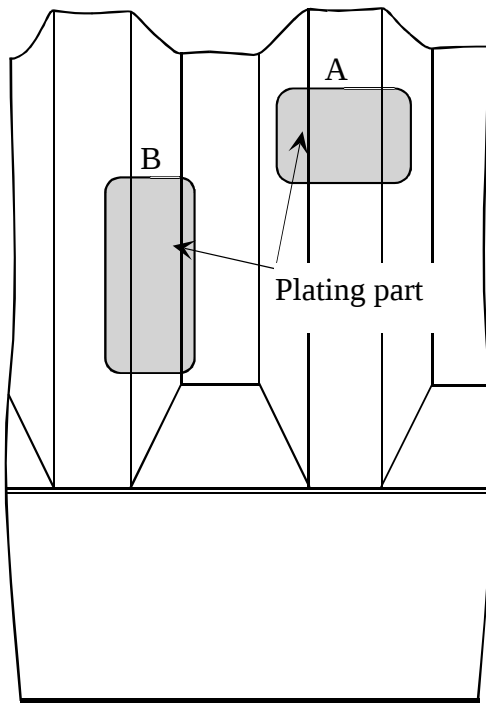
(d) **Fractures in the weld connections of the corrugations to the hopper tank, topside tank or to the deck in the vicinity of the hatchway opening**

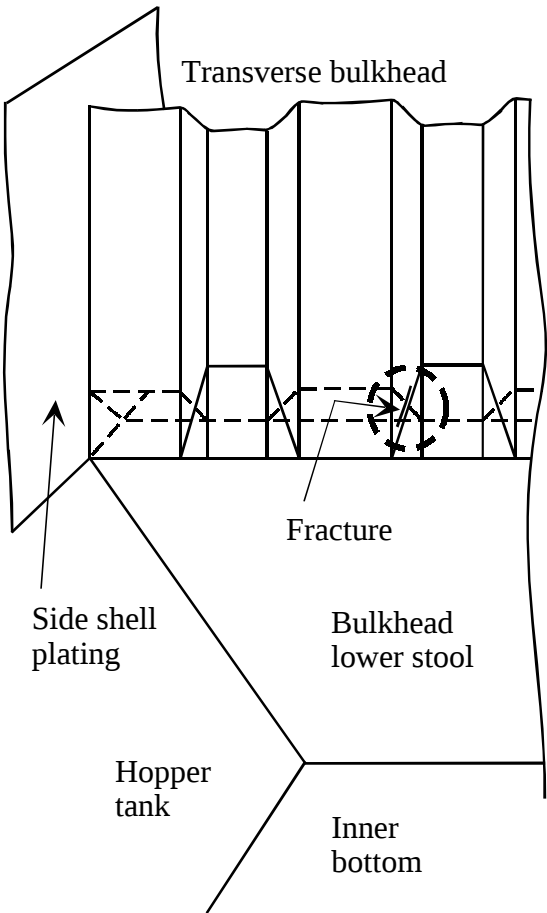
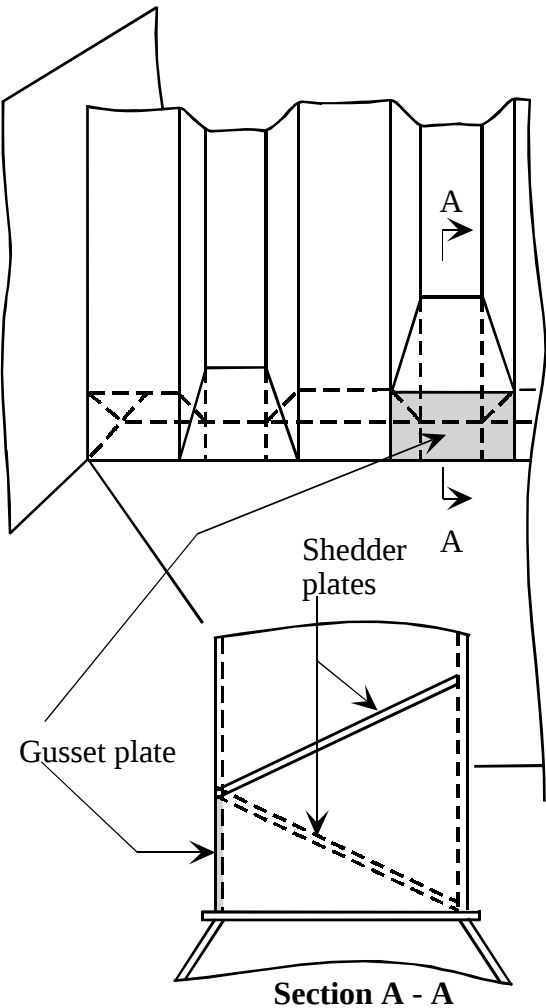
It is recommended that the weld connection be repaired as indicated in **4.3.1** and, where possible, additional stiffening be fitted inside the tanks to align with the flanges of the corrugations, or on the under deck clear of the tanks.

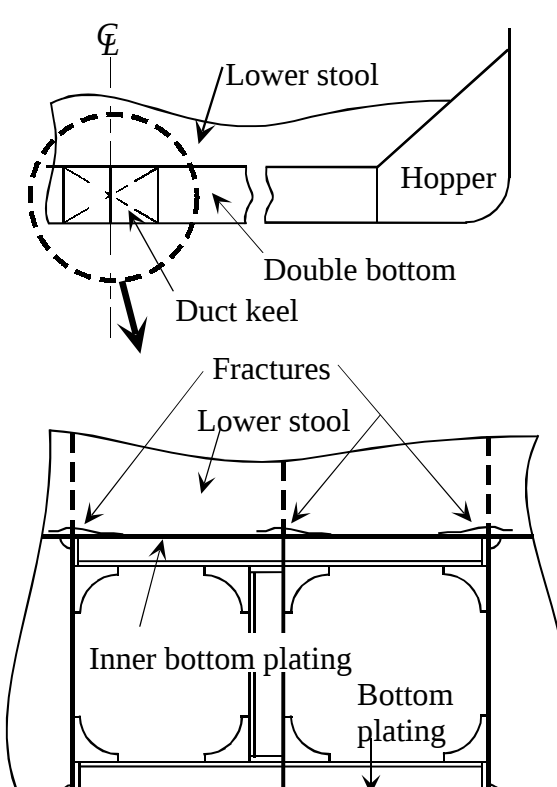
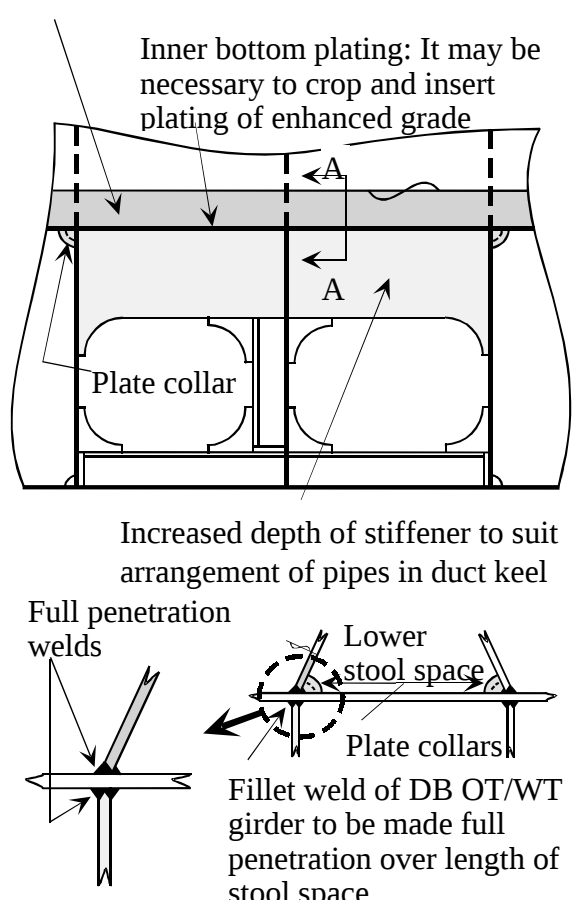
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 4	Transverse bulkhead and associated structure in cargo hold	1-a	
Detail of damage		Fractures at weld connections to stool shelf plate	
Sketch of damage		Sketch of repair	
 The sketch of damage consists of two parts. The top part is a cross-sectional view of a bulkhead corrugation connected to a shelf plate. It shows fractures at the weld connections. The bottom part is a plan view showing the shedder plate, fractures, and stool sloping plating.		 The sketch of repair consists of two parts. The top part is a cross-sectional view showing the repair of the bulkhead corrugation to the shelf plate. It shows edges prepared and full penetration welded on both sides, a vertical stiffener added where there is an indication of buckling, a new sloping plate insert of increased thickness, and a welded plate collar. The bottom part is a plan view labeled 'View A-A' showing the repair of the stool sloping plating.	
Notes on possible cause of damage		Notes on repairs	
1. Stress concentrations at welds adjacent to the scallops. 2. Inadequate welding area connecting corrugation flange to shelf plate or similarly sloping stool plating to shelf plate. 3. Inadequate thickness of sloping plating in relation to corrugation flange thickness. 4. Stress concentration at knuckle of corrugation where web is not supported by bracket inside the stool.		1. Fractures to be veed-out and rewelded. 2. Reductions in stress concentration by fitting welded plate collars in way of the scallop. 3. Where necessary an insert plate to be arranged in stool plating and/or diaphragm.	

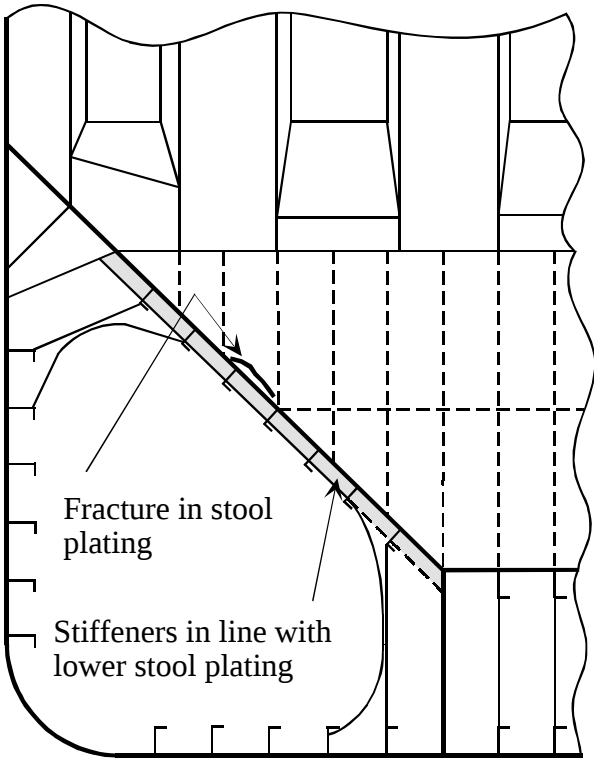
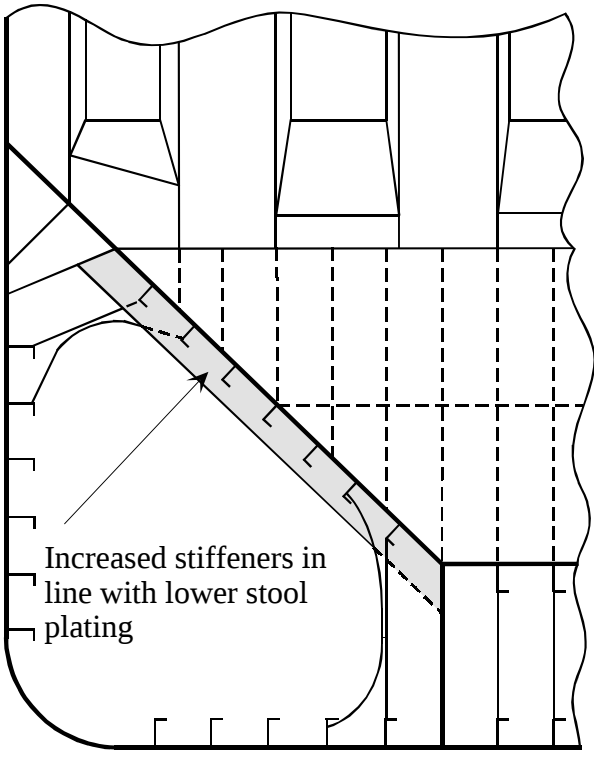
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 4	Transverse bulkhead and associated structure in cargo hold	1-b	
Detail of damage		Fractures at weld connections to stool shelf plate	
Sketch of damage		Sketch of repair	
 The sketch of damage illustrates two views of structural failure. The top view shows a cross-section of a bulkhead corrugation connected to a shelf plate. Red lines indicate fractures at the weld connections. The bottom view shows a side elevation of the stool sloping plating and shedder plate, with a fracture indicated at the weld connection to the shelf plate.		 The sketch of repair shows the same structural components after repair. The welds at the connections between the bulkhead corrugation, shelf plate, and stool sloping plating are shown as full penetration welds. A label indicates: "Edges prepared and full penetration welded, using low hydrogen electrodes or equivalent".	
Notes on possible cause of damage		Notes on repairs	
1. Misalignment between corrugation flange and sloping stool plating. 2. Inadequate welding area connecting corrugation flange to shelf plate or similarly sloping stool plating to shelf plate.		1. Fractures to be veed-out and rewelded. 2. Structure to be released and misalignment rectified. 3. Edge of the corrugated bulkhead and the stool plating on both sides of shelf plate to have full penetration welds. 4. Where necessary an insert plate to be arranged in stool plating.	

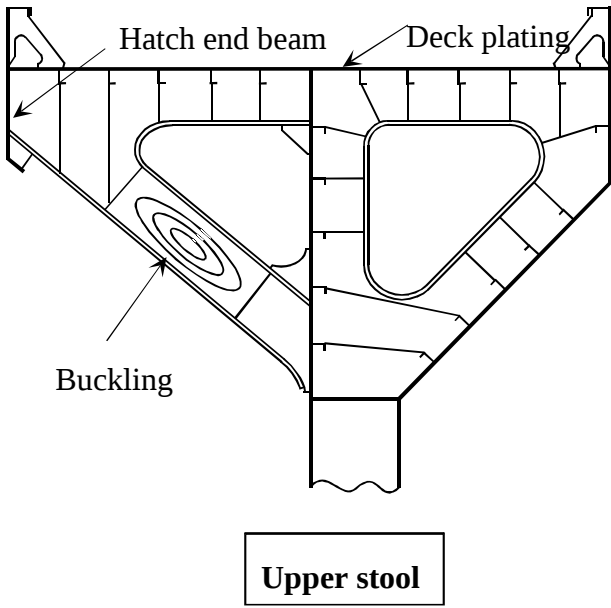
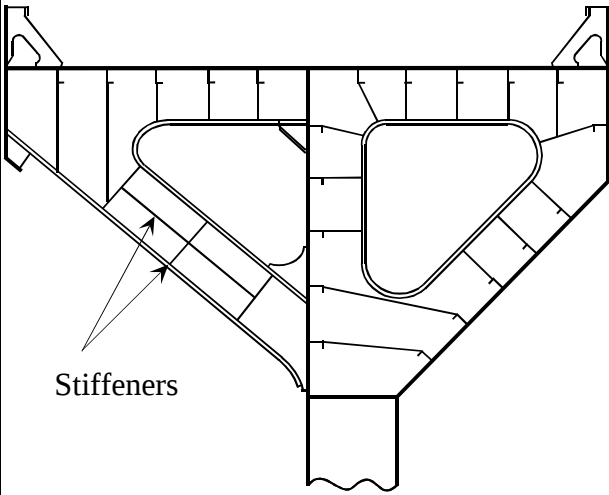
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 4	Transverse bulkhead and associated structure in cargo hold	2	
Detail of damage		Fractures at the upper boundaries to topside tanks	
Sketch of damage		Sketch of repair	
		Continuous or intercostal reinforcement in line with flanges or gussets where not already fitted Adjacent to the topside tank either a gusset to a bulb plate stiffener may be  Gusset (similar gusset on the opposite)	
Notes on possible cause of damage		Notes on repairs	
1. Damage due to poor design and/or defective welds.		1. Fractures may be veed-out and rewelded. If necessary corrugated plating cropped and renewed. 2. It is recommended that reinforcement as shown above be incorporated, giving due consideration to the following criteria: 2.1 It is important to have the gusset plates well aligned with the transverse structure inside the tank. Gusset plates may be joggled to obtain this alignment. 2.2 If there is no transverse web already existing inside the topside tank and in line with the flanges of corrugation or gusset plates, reinforcement as shown above to be fitted.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 4	Transverse bulkhead and associated structure in cargo hold	3	
Detail of damage		Indentation and buckling of vertical corrugation	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Damages by mechanical abuse during cargo handling e.g. grab damage. 2. Damage resulting from thickness reduction by corrosion. 3. Buckling caused by bending or shear, see locations A and B respectively above, with a minimum reduction in thickness could be caused by underdesign or overloading. If this cause is suspected, the CCS concerned shall be contacted before proceeding with repairs.		1. Damage by mechanical abuse If the indentation/buckling is local and of a minor nature, the plating can be faired in place. If the deformation is more pronounced and/or in association with a generalized reduction in thickness the plating is to be cropped and renewed, as shown at locations A and B above. 2. Damage resulting from corrosion In this case thickness measurements are to be taken at mid-span and top and bottom of corrugations, and corrugations renewed or part renewed as necessary. Particular attention is to be given to the fit and alignment at corners of flanged corrugations when being partly renewed.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 4	Transverse bulkhead and associated structure in cargo hold	4	
Detail of damage		Fractures in the web of the corrugation initiating at intersection of adjacent shedder plates	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Damage due to stress concentrations at intersection of shedder plates. This can be exacerbated by corrosion and reduction in thickness of the corrugation web plating.		1. If due to wastage, corrugation plating and shedder plates to be part renewed/renewed as necessary. 2. Where renewals are being carried out it may be prudent to fit the extension pieces shown above to change the location of the point of intersection, and hence reduce the stress concentration.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 4	Transverse bulkhead and associated structure in cargo hold	5	
Detail of damage		Fractures at weld connection of lower stool plating to inner bottom in way of duct keel	
Sketch of damage 		Sketch of repair Lower stool: Insert plate of increased Inner bottom plating: It may be necessary to crop and insert plating of enhanced grade  Increased depth of stiffener to suit arrangement of pipes in duct keel Full penetration welds Lower stool space Plate collars Fillet weld of DB OT/WT girder to be made full penetration over length of stool space View A - A	
Notes on possible cause of damage 1. This type of failure is more likely to occur at the boundaries of the ballast hold. 2. The fractures arise because of stress concentration in way of cut-outs and exacerbated by the flexibility of the inner bottom structure in way of the duct keel.		Notes on repairs 1. In order to prevent recurrence of the damage, the additional reinforcement shown should be fitted.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 4	Transverse bulkhead and associated structure in cargo hold	6	
Detail of damage		Fractures at the connection of lower stool to hopper	
Sketch of damage		Sketch of repair	
 Fracture in stool plating Stiffeners in line with lower stool plating		 Increased stiffeners in line with lower stool plating	
Notes on possible cause of damage		Notes on repairs	
1. Insufficient strength of the connection 2. Corrosion		1. Fractured stool plating should be partly cropped and renewed (thicker plate) if considered necessary. 2. If the damage occurred due to insufficient strength, stiffeners in line with stool plating should be increased.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 4	Transverse bulkhead and associated structure in cargo hold	7	
Detail of damage		Buckling of strut supporting hatch end beam	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Insufficient strength 2. Partial ballast loading in ballast cargo hold (sloshing) 3. Corrosion		1. Deformed part to be cropped and renewed if considered necessary. 2. If the damage occurred due to insufficient strength, appropriate reinforcement is to be considered (thicker plate / additional stiffener(s)).	

Area 5 Double bottom tank structure including hopper

Contents

1 General

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- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 What to look for - Double bottom and hopper tank inspection

- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

4 What to look for - External bottom inspection

- 4.1 Material wastage
- 4.2 Deformations
- 4.3 Fractures

5 General comments on repair

- 5.1 Material wastage
- 5.2 Deformations
- 5.3 Fractures

Figures and/or Photographs - Area 5	
No.	Title
Figure 1	Typical fractures in the connection of hopper plating and inner bottom plating
Photograph 1	Grooving corrosion of weld of bottom plating
Photograph 2	Section of the grooving shown in Photograph 1

Examples of structural detail failures and repairs - Area 5	
Example No.	Title
1	Fractures in inner bottom plating around container bottom pocket
2	Fractures, corrosion and/or buckling of floor/girder around lightening hole
3	Fractures at weld connections of floors in way of hopper/inner bottom interface (radiused knuckle)
4	Fractures at weld connections of floors in way of hopper/inner bottom interface (welded knuckle)

Examples of structural detail failures and repairs - Area 5	
Example No.	Title
5	Fractures at weld connections of floors in way of inner bottom and side girders, and plating of bulkhead stool
6	Fractures and buckling in way of a cut-out for the passage of a longitudinal through a transverse primary member
7	Fractures in longitudinal at floor/transverse web frame or bulkhead
8	Fractures in bottom and inner bottom longitudinals in way of inner bottom and bulkhead stool boundaries
9	Fractures in longitudinals in way of bilge well
10	Buckling of transverse web
11	Fractures at weld connection of the transverse brackets
12	Fractures in bottom shell/side shell/hopper sloping plating at the corner of drain hole/air hole in longitudinal
13	Fractures in bottom shell plating along side girder and/or bottom longitudinal
14	Corrosion in bottom shell plating below suction head
15	Corrosion in bottom shell plating below sounding pipe
16	Deformation of forward bottom shell plating due to slamming
17	Fractures in bottom shell plating at the termination of bilge keel

1 General

- 1.1** In addition to contributing to the longitudinal bending strength of the hull girder, the double bottom structure provides support for the cargo in the holds. The tank top structure is subjected to impact forces of cargo and mechanical equipment during cargo loading and unloading operations. The bottom shell at the forward part of the ship may sustain increased dynamic forces caused by slamming in heavy weather.
- 1.2** Double bottom tank structure in way of combined cargo/ballast hold(s) is more prone to fractures and deformation compared to the structure in way of holds dedicated for carriage of cargo.
- 1.3** The weld at the connections of the tank top/hopper sloping plate and tank top/bulkhead stool may suffer damage caused by the use of bulldozers to unloading cargo.

2 What to look for - Tank top inspection

2.1 Material wastage

- 2.1.1** The general corrosion condition of the tank top structure may be observed by visual inspection. The level of wastage of tank top plating may have to be established by means of thickness measurement.
- 2.1.2** The bilge wells should be cleaned and inspected closely since heavy pitting corrosion may have occurred due to accumulated water/corrosive solution in the wells. Special attention should be paid to the plating in way of the bilge suction and sounding pipes.
- 2.1.3** Special attention should also be paid to areas where pipes penetrate the tank top.

2.2 Deformations

- 2.2.1** Buckling of the tank top plating may occur between longitudinals in areas subject to in-plane transverse compressive stresses or between floors in areas subject to in-plane longitudinal compressive stresses.
- 2.2.2** Deformed structures may be observed in areas of the tank top due to overloading of cargo, impact of cargo during loading/unloading operations, or the use of mechanical unloading equipment.
- 2.2.3** Whenever deformations are observed on the tank top, further inspection in the double bottom tanks is imperative in order to determine the extent of the damage. The deformation may cause the breakdown of coating within the double bottom, which in turn may lead to accelerated corrosion rate in these unprotected areas.

2.3 Fractures

- 2.3.1** Fractures will normally be found by close-up inspection. Fractures that

extend through the thickness of the plating or through the welds may be observed during pressure testing of the double bottom tanks (See **Figure 1** and **2** of **Area 4**).

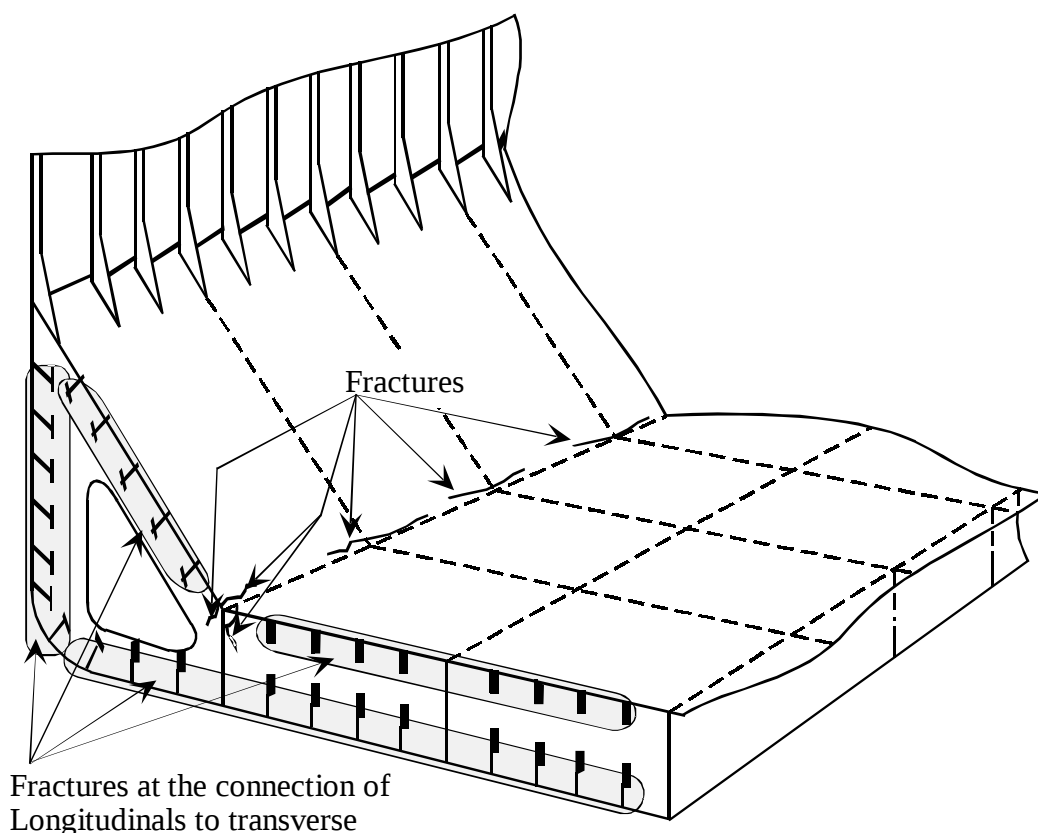


Figure 1 Typical fractures in the connection of hopper sloping plating to inner bottom (tank top) and longitudinals to transverse (or transverse bulkhead)

3 What to look for - Double bottom and hopper tank inspection

3.1 Material wastage

3.1.1 The level of wastage of double bottom internal structure (longitudinals, transverses, floors, girders, etc.) may have to be established by means of thickness measurements.

Rate and extent of corrosion depends on the corrosive environment, and protective measures employed, such as coatings and sacrificial anodes. The following structures are generally susceptible to corrosion (also see **3.1.2 - 3.1.4**).

- (a) Structure in corrosive environment
 - Back side of inner bottom plating and inner bottom longitudinal
 - Transverse bulkhead and girder adjacent to heated fuel oil tank
- (b) Structure subject to high stress
 - Face plates and web plates of transverse at corners

- Connection of longitudinal to transverse
- (c) Areas susceptible to coating breakdown
 - Back side of face plate of longitudinal
 - Welded joint
 - Edge of access opening
- (d) Areas subject to poor drainage
 - Web of side longitudinals

3.1.2 If the protective coating is not properly maintained, structure in the ballast tank may suffer severe localised corrosion. In general, structure at the upper part of the double bottom tank usually has more severe corrosion than that at the lower part. Transverse webs in the hopper tanks may suffer severe corrosion at their corners where high shearing stresses occur, especially where collar plate is not fitted to the slot of the longitudinal.

3.1.3 The high temperature due to heated fuel oil may accelerate corrosion of ballast tank structure near heated fuel tanks. The rate of corrosion depends on several factors such as:

- Temperature and heat input to the ballast tank.
- Condition of original coating and its maintenance. (It is preferable for applying the protective coating of ballast tank at the building of the ship, and for subsequent maintenance, that the stiffeners on the boundaries of the fuel tank be fitted within the fuel tank instead of the ballast tank).
- Ballasting frequency and operations.
- Age of ship and associated stress levels as corrosion reduces the thickness of the structural elements and can result in fracturing and buckling.

3.1.4 Shell plating below suction head often suffers localized wear caused by erosion and cavitation of the fluid flowing through the suction head. In addition, the suction head will be positioned in the lowest part of the tank and water/mud will cover the area even when the tank is empty. The condition of the shell plating may be established by feeling by hand beneath the suction head. When in doubt, the lower part of the suction head should be removed and thickness measurements taken. If the vessel is docked, the thickness can be measured from below. If the distance between the suction head and the underlying shell plating is too small to permit access, the suction head should be dismantled. The shell plating below the sounding pipe should also be carefully examined. When a striking plate has not been fitted or is worn out, heavy corrosion can be caused by the striking of the weight of the sounding tape (See **Example 2 in Part 3**).

3.2 Deformations

3.2.1 Where deformations are identified during tank top inspection (See **2.2**) and external bottom inspection (See **4.2**), the deformed areas should be subjected to in tank inspection to determine the extent of the damage to

the coating and internal structure.

Deformations in the structure not only reduce the structural strength but may also cause breakdown of the coating, leading to accelerated corrosion.

3.3 Fractures

3.3.1 Fractures will normally be found by close-up inspection.

3.3.2 Fractures may occur in way of the welded or radiused knuckle between the inner bottom and hopper sloping plating if the side girder in the double bottom is not in line with the knuckle and also when the floors below have a large spacing, or when corner scallops are created for ease of fabrication. The local stress variations due to the loading and subsequent deflection may lead to the development of fatigue fractures which can be categorised as follows (See **Figure 1**).

- (a) Parallel to the knuckle weld for those knuckles which are welded and not radiused.
- (b) In the inner bottom and hopper plating and initiated at the centre of a radiused knuckle.
- (c) Extending in the hopper web plating and floor weld connections starting at the corners of scallops, where such exist, in the underlying hopper web and floor.
- (d) Extending in the web plate as in (c) above but initiated at the edge of a scallop.

3.3.3 The fractures in way of connection of inner bottom plating/hopper sloping plating to stool may be caused by the cyclic deflection of the inner bottom induced by repeated loading from the sea or due to poor “through-thickness” properties of the inner bottom plating. Scallops in the underlying girders can create stress concentrations which further increase the risk of fractures. These can be categorised as follows (See **Figure 1** and **Examples**).

- (a) In way of the intersection between inner bottom and stool. These fractures often generate along the edge of the welded joint above the centre line girder, side girders, and sometimes along the duct keel sides.
- (b) Fractures in the inner bottom longitudinals and the bottom longitudinals in way of the intersection with the watertight floors below the transverse bulkhead stools in way of the ballast hold, especially in way of suction wells.
- (c) Fractures at the connection between the longitudinals and the vertical stiffeners or brackets on the floors, as well as at the corners of the duct keel.
- (d) Lamellar tearing of the inner bottom plate below the weld connection with the stool in the ballast hold caused by large bending stresses in the connection when in heavy ballast condition. The size of stool and lack of full penetration welds could also be a contributory factor, as well as poor “through-thickness” properties of the tank top plating.

3.3.4 Transition region

In general, the termination of the following structural members at the collision bulkhead and engine room forward bulkhead is prone to fractures:

- Hopper tank sloping plating
- Panting stringer in fore peak tank
- Inner bottom plating in engine room

In order to avoid stress concentration due to discontinuity appropriate stiffeners are to be provided in the opposite space. If such stiffeners are not provided, or are deficient due to corrosion or misalignment, fractures may occur at the terminations.

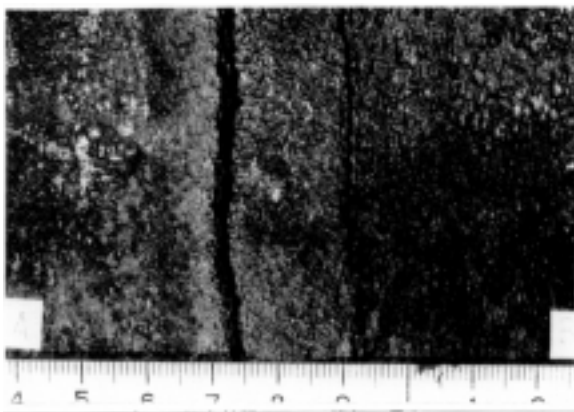
4 What to look for - External bottom inspection

4.1 Material wastage

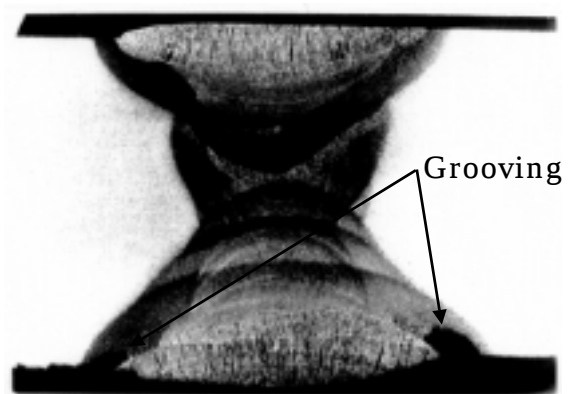
4.1.1 Hull structure below the water line can usually be inspected only when the ship is dry-docked. The opportunity should be taken to inspect the external plating thoroughly. The level of wastage of the bottom plating may have to be established by means of thickness measurements.

4.1.2 Severe grooving along welding of bottom plating is often found (See **Photographs 1** and **2**). This grooving can be accelerated by poor maintenance of the protective coating and/or sacrificial anodes fitted to the bottom plating.

4.1.3 Bottom or “docking” plugs should be carefully examined for excessive corrosion along the edge of the weld connecting the plug to the bottom plating.



Photograph 1
Grooving corrosion of welding of bottom plating



Photograph 2
Section of the grooving shown in Photograph 1

4.2 Deformations

4.2.1 Buckling of the bottom shell plating may occur between longitudinals or floors in areas subject to in-plane compressive stresses (either longitudinally or transversely). Deformations of bottom plating may also

be attributed to dynamic force caused by wave slamming action at the forward part of the vessel, or contact with underwater objects. When deformation of the shell plating is found, the affected area should be inspected internally. Even if the deformation is small, the internal structure may have suffered serious damage.

4.3 Fractures

4.3.1 The bottom shell plating should be inspected when the hull has dried since fractures in shell plating can easily be detected by observing leakage of water from the cracks in clear contrast to the dry shell plating.

4.3.2 Fractures in butt welds and fillet welds, particularly at the wrap around at scallops and ends of bilge keel, are sometimes observed and may propagate into the bottom plating. The cause of fractures in butt welds is usually related to weld defect or grooving. If the bilge keels are divided at the block joints of hull, all ends of the bilge keels should be inspected.

5 General comments on repair

5.1 Material wastage

5.1.1 Repair work in double bottom will require careful planning in terms of accessibility and gas freeing is required for repair work in fuel oil tanks.

5.1.2 Plating below suction heads and sounding pipes is to be replaced if the average thickness is below the acceptable limit (See **Examples 14** and **15**). When scattered deep pitting is found, it may be repaired by welding.

5.2 Deformations

Extensively deformed tank top and bottom plating should be replaced together with the deformed portion of girders, floors or transverse web frames. If there is no evidence that the deformation was caused by grounding or other excessive local loading, or that it is associated with excessive wastage, additional internal stiffening may need to be provided. In this regard, the CCS concerned should be contacted.

5.3 Fractures

5.3.1 Repair should be carried out in consideration of nature and extent of the fractures.

- (a) Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed.
- (b) For fractures caused by the cyclic deflection of the double bottom, reinforcement of the structure may be required in addition to cropping and renewal of the fractured part.
- (c) For fractures due to poor through thickness properties of the plating, cropping and renewal with steel having adequate through thickness properties is an acceptable solution.

5.3.2 The fractures in the knuckle connection between inner bottom plating

and hopper sloping plating should be repaired as follows.

- (a) Where the fracture is confined to the weld, the weld is to be veed-out and renewed using full penetration welding, with low hydrogen electrodes or equivalent.
- (b) Where the fracture has extended into the plating of any tank boundary, then the fractured plating is to be cropped, and part renewed.
- (c) Where the fracture is in the vicinity of the knuckle, the corner scallops in floors and transverses are to be omitted, or closed by welded collars. The sequence of welding is important, in this respect every effort should be made to avoid the creation of locked in stresses due to the welding process.
- (d) Where the floor spacing is 2.0m or greater, brackets are to be arranged either in the vicinity of, or mid-length between, floors in way of the intersection. The brackets are to be attached to the adjacent inner bottom and hopper longitudinals. The thickness of the bracket is to be in accordance with the Rules of the CCS concerned.
- (e) If the damage is confined to areas below the ballast holds and the knuckle connection is of a radiused type, then in addition to rectifying the damage (i.e. weld or crop and renew), consideration is to be given to fitting further reinforcement, e.g. longitudinals or scarfing brackets, in the vicinity of the upper tangent point of the radius.

5.3.3 The fractures in the connection between inner bottom plating/hopper sloping plating and stool should be repaired as follows.

- (a) Fractures in way of section of the inner bottom and bulkhead stool in way of the double bottom girders can be veed out and welded. However, reinforcement of the structure may be required, e.g. by fitting additional double bottom girders on both sides affected girder or equivalent reinforcement. Scallops in the floors should be closed and air holes in the non-watertight girders re-positioned.

If the fractures are as a result of differences in the thickness of adjacent stool plate and the floor below the inner bottom, then it is advisable to crop and part renew the upper part of the floor with plating having the same thickness and mechanical properties as the adjacent stool plating.

If the fractures are as a result of misalignment between the stool plating and the double bottom floors, the structure should be released with a view to rectifying the misalignment.

- (b) Fractures in the inner bottom longitudinals and the bottom longitudinals in way of the intersection with watertight floors are to be cropped and partly renewed. In addition, brackets with soft toes are to be fitted in order to reduce the stress concentrations at the floors or stiffener.
- (c) Fractures at the connection between the longitudinals and the vertical stiffeners or brackets are to be cropped and longitudinal part

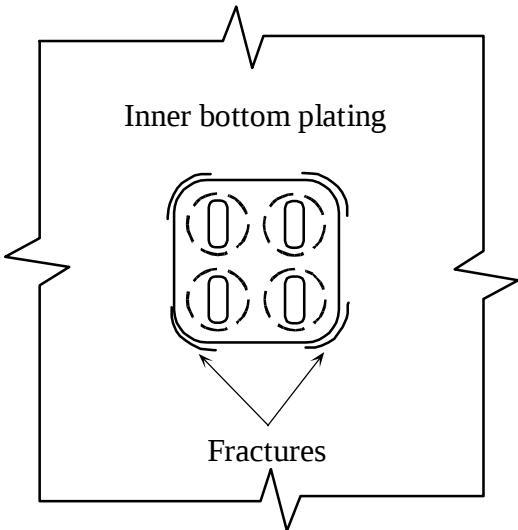
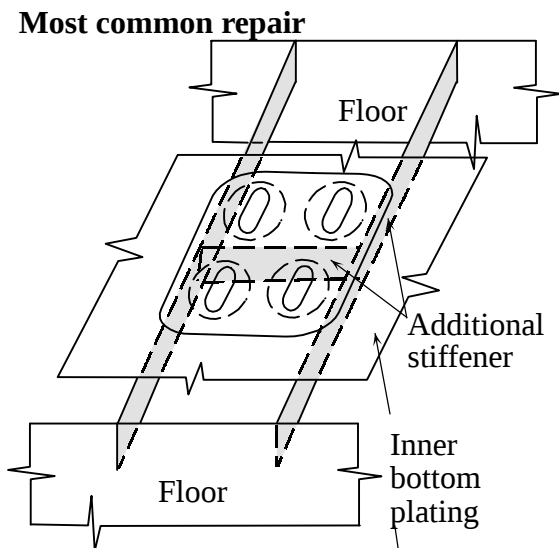
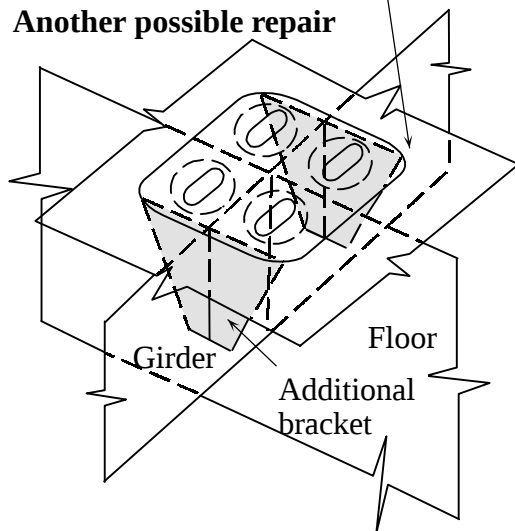
renewed if the fractures extend to over one third of the depth of the longitudinal. If fractures are not extensive these can be veed out and welded. In addition, reinforcement should be provided in the form of modification to existing bracket toes or the fitting of additional brackets with soft toes in order to reduce the stress concentration.

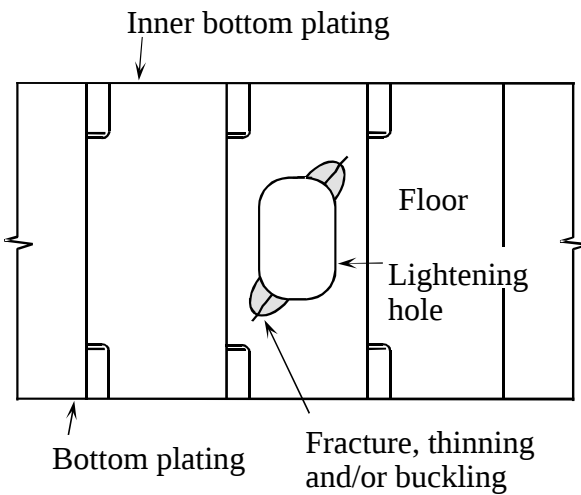
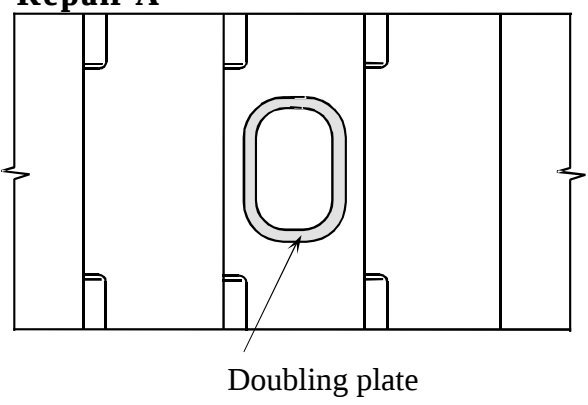
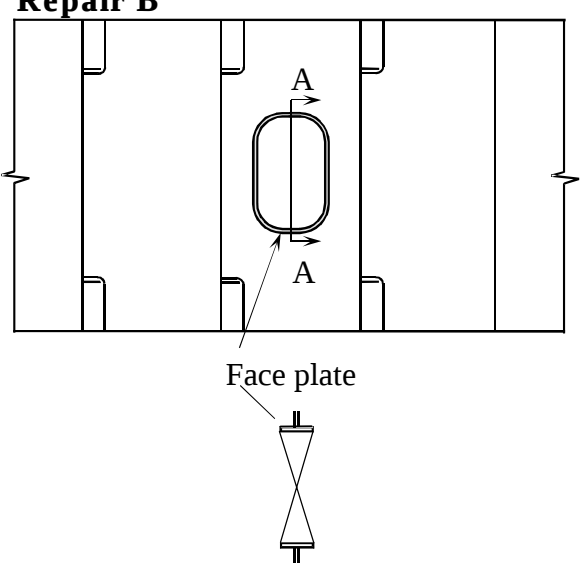
- (d) Fractures at the corners of the transverse diaphragm/stiffeners are to be cropped and renewed. In addition, scallops are to be closed by overlap collar plates. To reduce the probability of such fractures recurring, consideration is to be given to one of the following reinforcements or modifications.
 - The fitting of short intercostal girders in order to reduce the deflection at the problem area.
 - The depth of transverse diaphragm/stiffener at top of duct keel is to be increased as far as is practicable to suit the arrangement of pipes.
- (e) Lamellar tearing may be eliminated through improving the type and quality of the weld, i.e. full penetration using low hydrogen electrodes and incorporating a suitable weld throat.

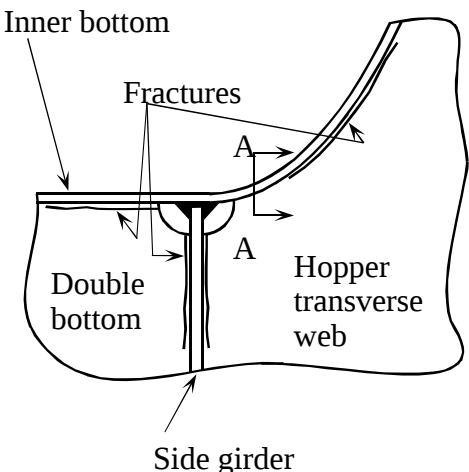
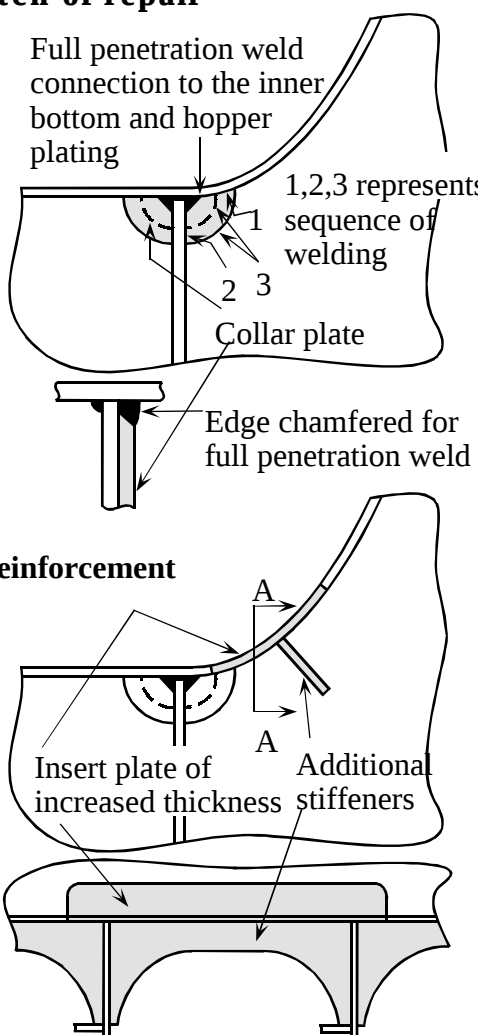
Alternatively the inner bottom plating adjacent to and in contact with the stool plating is substituted with plating of “Z” quality steel which has good “through-thickness” properties.

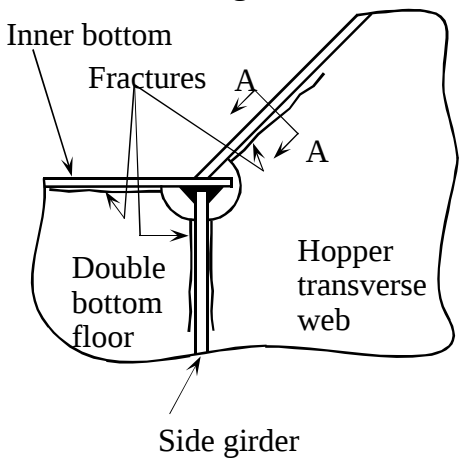
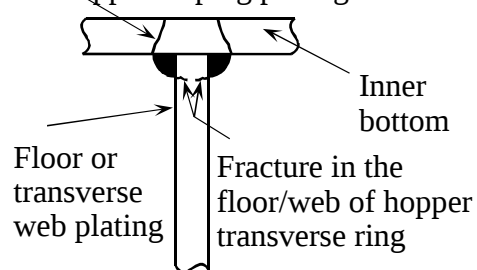
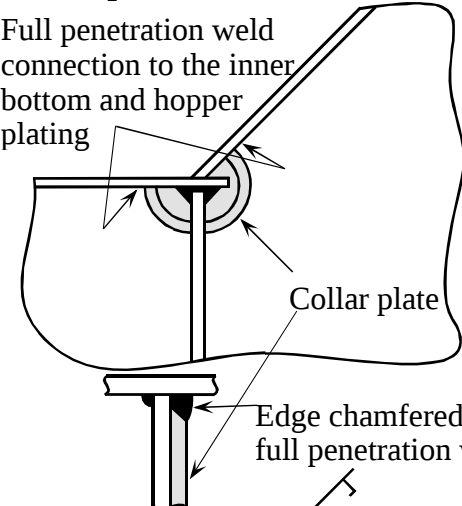
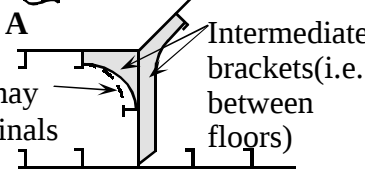
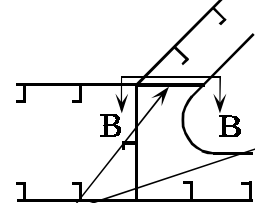
5.3.4 Bilge keel should be repaired as follows.

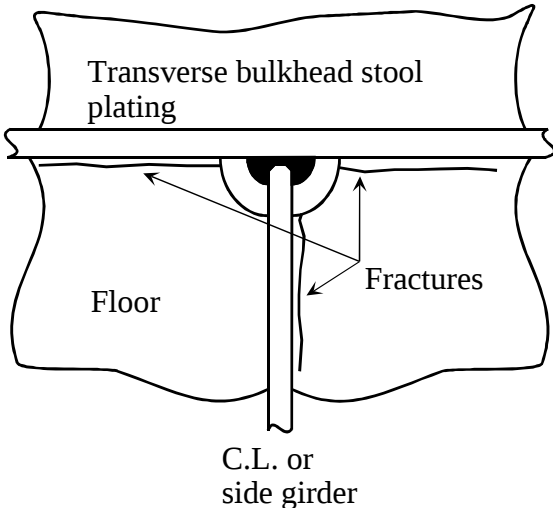
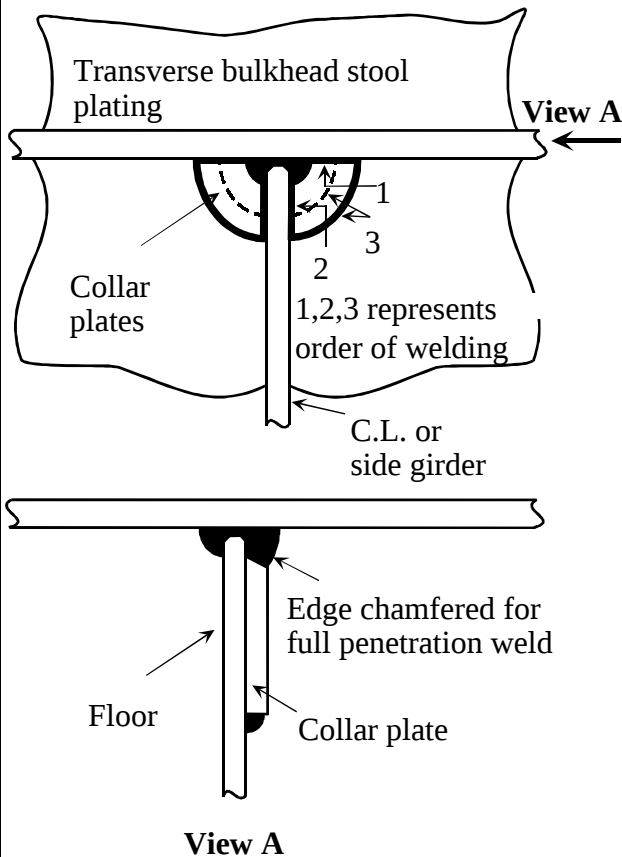
- (a) Fractures or distortion in bilge keels must be promptly repaired. Fractured butt welds should be repaired using full penetration welds and proper welding procedures. The bilge keel is subjected to the same level of longitudinal hull girder stress as the bilge plating, fractures in the bilge keel can propagate into the shell plating.
- (b) Termination of bilge keel requires proper support by internal structure. This aspect should be taken into account when cropping and renewing damaged parts of a bilge keel (See **Example 17**).

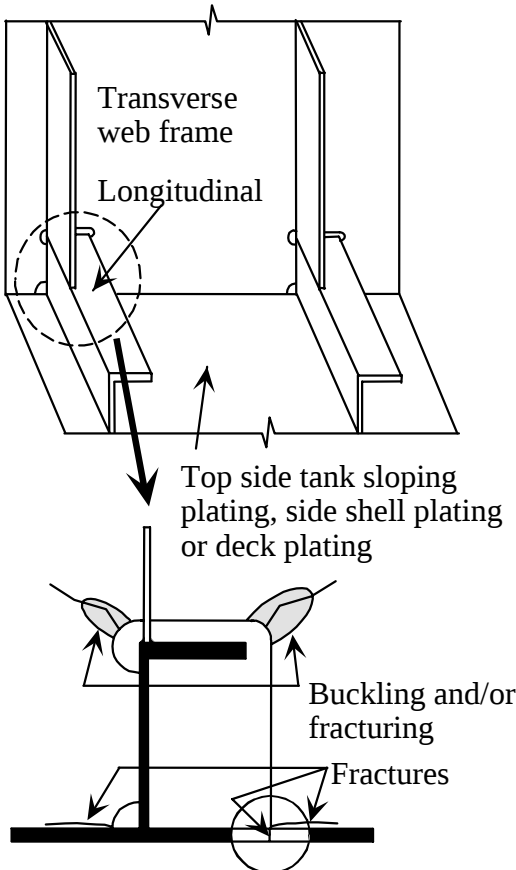
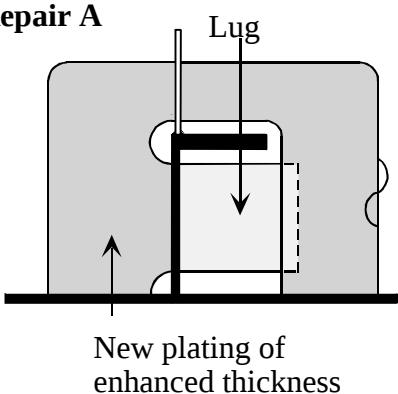
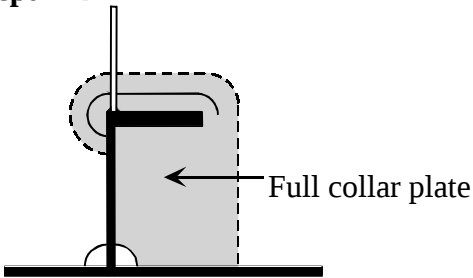
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No. 1	
Area 5	Double bottom structure including hopper	1	
Detail of damage		Fractures in inner bottom plating around container bottom pocket	
Sketch of damage		Sketch of repair	
		Most common repair  Another possible repair 	
Notes on possible cause of damage		Notes on repairs	
1. Pocket is not supported correctly by floor, longitudinal and/or stiffener.		1. Fractured plating should be cropped and part renewed. 2. Adequate reinforcement should be considered.	

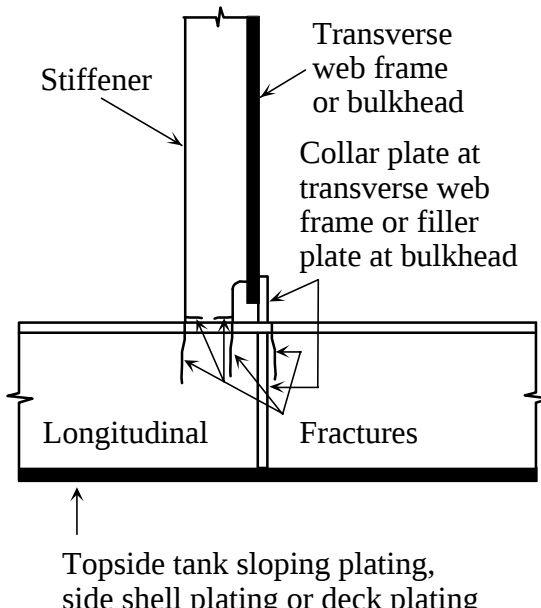
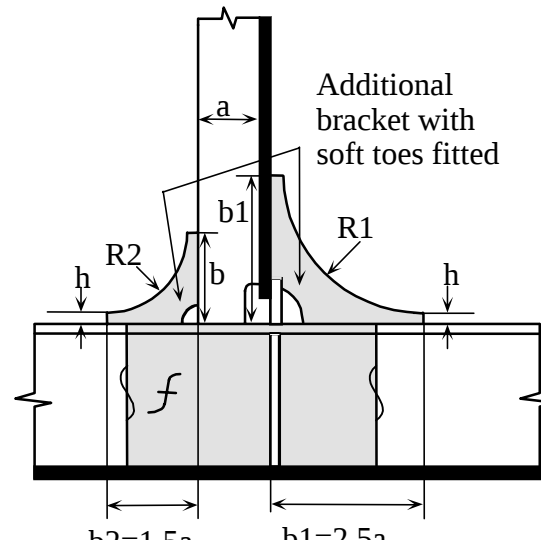
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 5	Double bottom structure including hopper		2
Detail of damage		Fractures, corrosion and/or buckling of floor/girder around lightening hole	
Sketch of damage  Inner bottom plating Floor Lightening hole Bottom plating Fracture, thinning and/or buckling		Sketch of repair Repair A  Doubling plate Repair B  Face plate Section A-A	
Notes on possible cause of damage 1. Insufficient strength due to lightening hole. 2. Fracture, corrosion and/or buckling around lightening hole due to high stress.		Notes on repairs 1. Fractured, corroded and/or buckled plating should be cropped and renewed if considered necessary. 2. Appropriate reinforcement should be considered.	

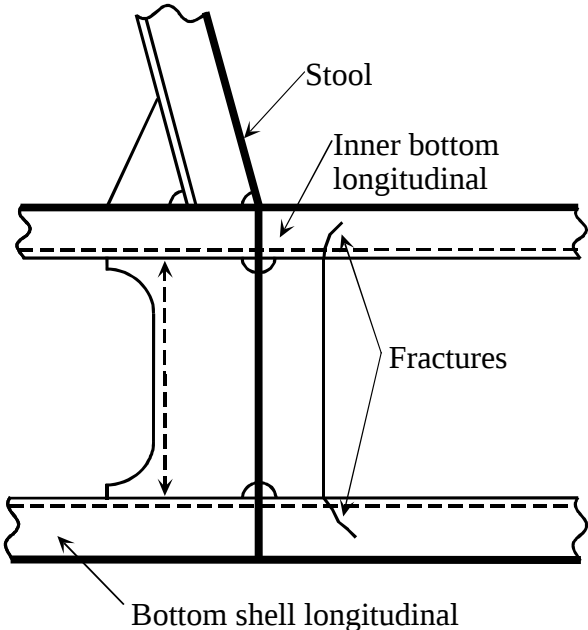
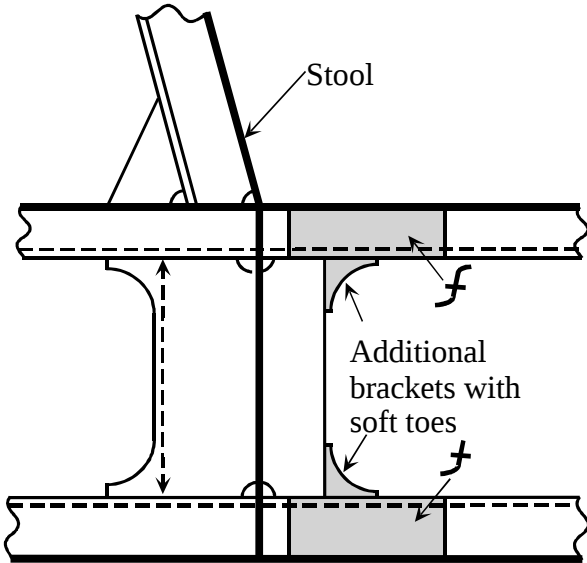
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	3
Detail of damage		Fractures at weld connections of floors in way of hopper/inner bottom interface (radiused knuckle)
Sketch of damage		Sketch of repair
 View A - A Transverse fractures in hopper web plating into possibly extending into the hopper sloping plating Inner bottom Floor or transverse web plating Fracture in the floor/web of hopper transverse ring		 Full penetration weld connection to the inner bottom and hopper plating 1,2,3 represents sequence of welding Collar plate Edge chamfered for full penetration weld Reinforcement Insert plate of increased thickness Additional stiffeners
Notes on possible cause of damage		Notes on repairs
The damage is partly due to stress concentrations at the edges of the weld created by the presence of cut-outs and local stress variations caused by the deflections in the inner bottom / hopper plating.		- The fracture in the weld and/or plating is veed-out/cropped and renewed as appropriate. - The cut-outs are eliminated by introducing suitable collar plate with emphasis on edge preparation and sequence of welding as shown above. - Further reinforcements may need to be carried out as shown above, however, after consultation with the CCS concerned.

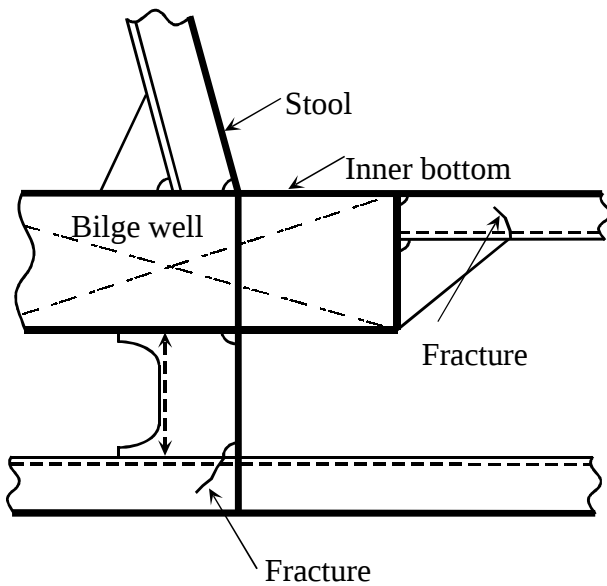
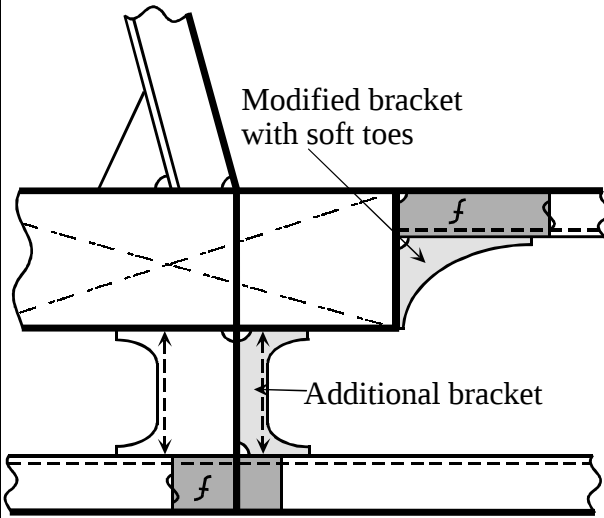
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 5	Double bottom tank structure including hopper	4	
Detail of damage		Fractures at weld connections of floors in way of hopper/inner bottom interface (welded knuckle)	
Sketch of damage		Sketch of repair	
 View A - A Transverse fractures in hopper web plating into possibly extending into the hopper sloping plating  Inner bottom Floor or transverse web plating Fracture in the floor/web of hopper transverse ring		 Reinforcement A Alternatively, may stop at longitudinals where fitted  Intermediate brackets (i.e. between floors) Reinforcement B  Scarfing brackets View B - B Face plate of transverse Inner bottom	
Notes on possible cause of damage		Notes on repairs	
1. The damage is partly due to stress concentration at the edges of the weld .created by the presence of the deflections in the inner bottom /hopper plating.		1. The fracture in the weld and/or plating is veed-out/cropped and renewed as appropriate. 2. The cut-outs are eliminated by introducing suitable collar plates with emphasis on edge preparation and sequence of welding as shown above. 3. Further reinforcements may be incorporated as shown above and depending on the judged cause of damage.	

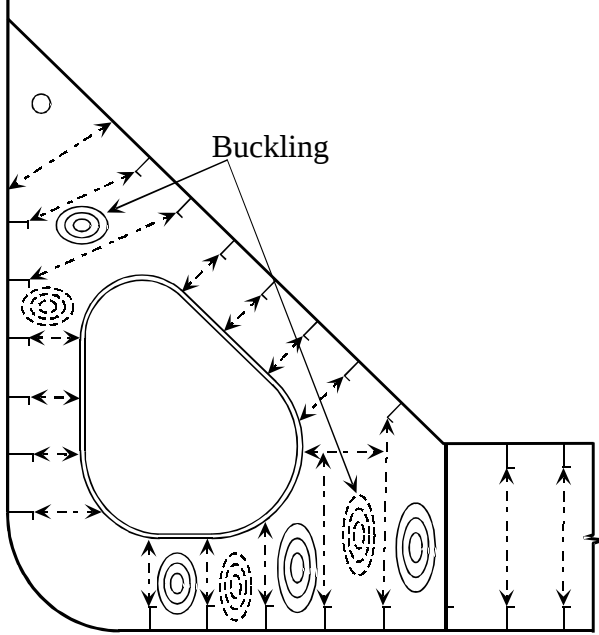
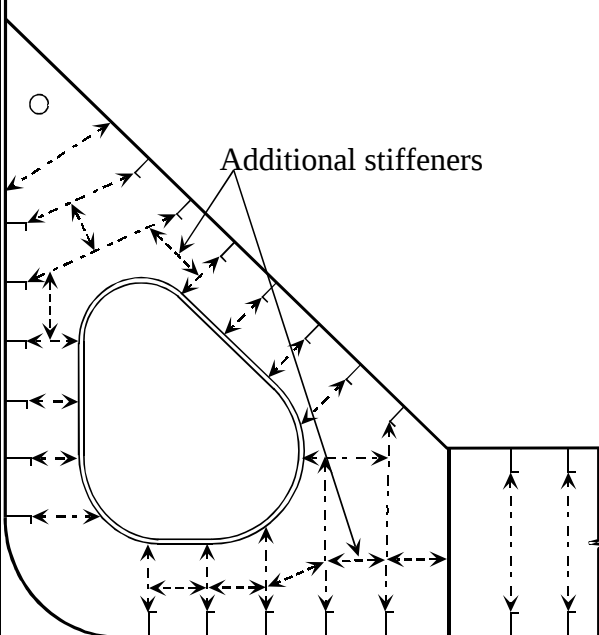
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 5	Double bottom tank structure including hopper	5	
Detail of damage		Fractures at weld connections of floors in way of inner bottom and side girders, and plating of bulkhead stool	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Stress concentration at the welds due to scallops.		1. The scallops will require to be fitted with welded collar plates to reduce stresses in the area.	

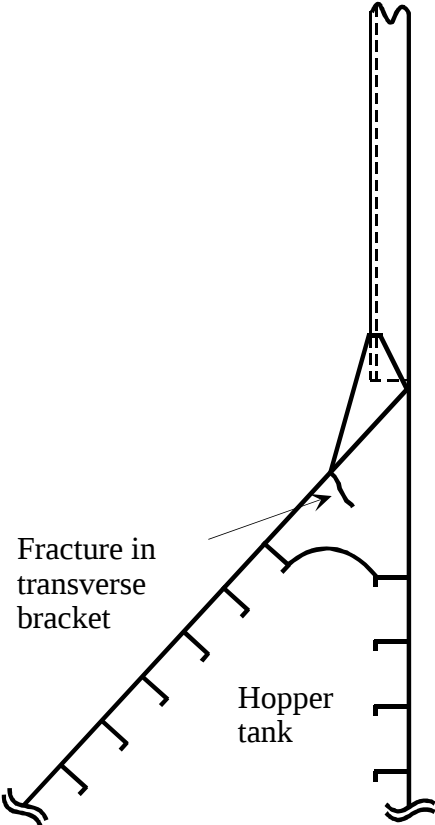
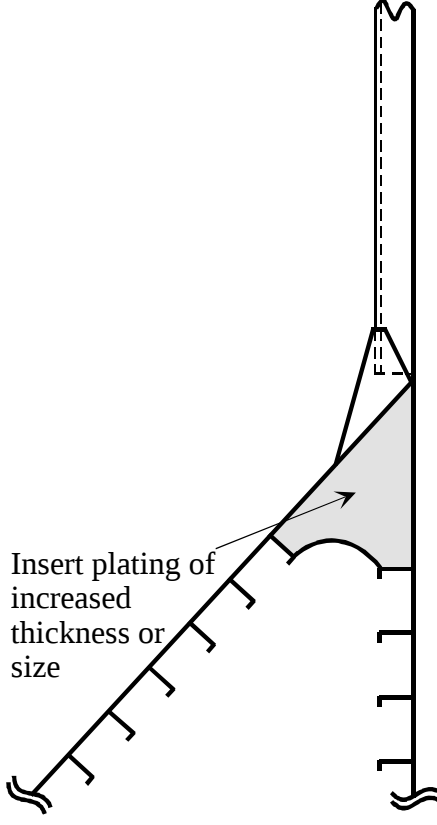
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure
Part 1	Cargo hold region	Example No.
Area 5	Double bottom tank structure including hopper	6
Detail of damage		Fractures and buckling in way of a cut-out for the passage of a longitudinal through a transverse primary member
Sketch of damage		Sketch of repair
		Repair A  Repair B 
Notes on possible cause of damage		Notes on repairs
Damage can be caused by general levels of corrosion and presence of stress concentration associated with the presence of a cut-out.		- If fractures are significant then crop and part renew the floor plating/transverse web otherwise the fracture can be veed-out and welded provided the plating is not generally corroded. Repair B is to be incorporated if the lug proves to be ineffective.

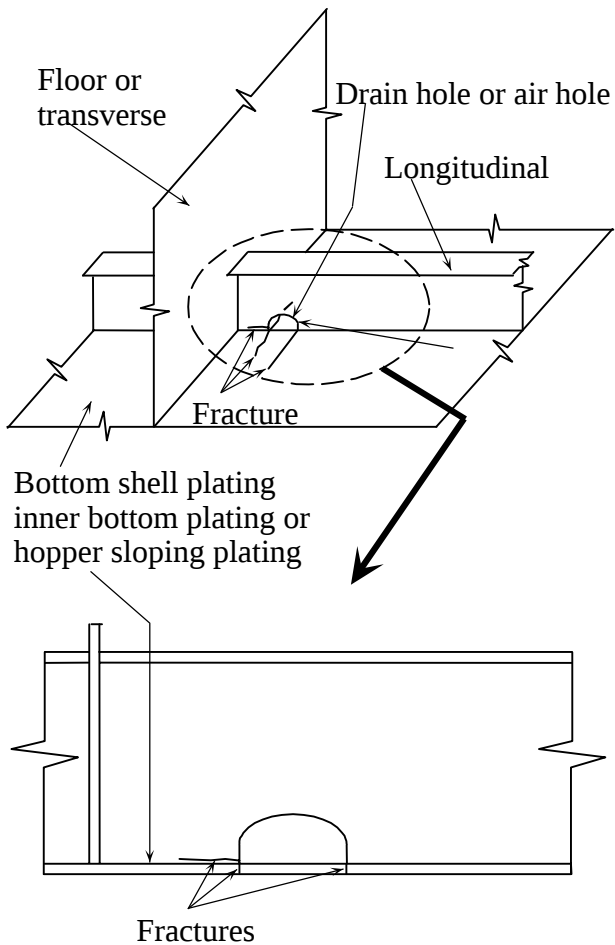
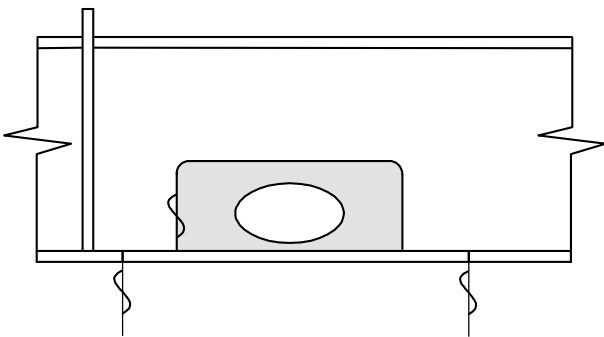
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 5	Double bottom tank structure including hopper	7	
Detail of damage		Fractures in longitudinal at floor/transverse web frame or bulkhead	
Sketch of damage		Sketch of repair	
		 f: Where required, the longitudinal to be cropped and part renewed 1. For a slope at toes max. 1:3, $R1 = (b1 - h) \times 1.6$ and $R2 = (b2 - h) \times 1.6$ 2. Soft toe bracket to be welded first to longitudinal 3. Scallop in bracket to be as small as possible, recommended max. 35mm 4. If toes of brackets are ground smooth, full penetration welds in way to be provided 5. Maximum length to thickness ratio = 50:1 for unstiffened bracket edge 6. Toe height, h, to be as small as possible (10-15mm)	
Notes on possible cause of damage		Notes on repairs	
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.		1. If fractures are not extensive e.g. hairline fractures, they can be veed-out and welded. 2. If fracture extends to over one third of the depth of the longitudinal then crop and part renew.	

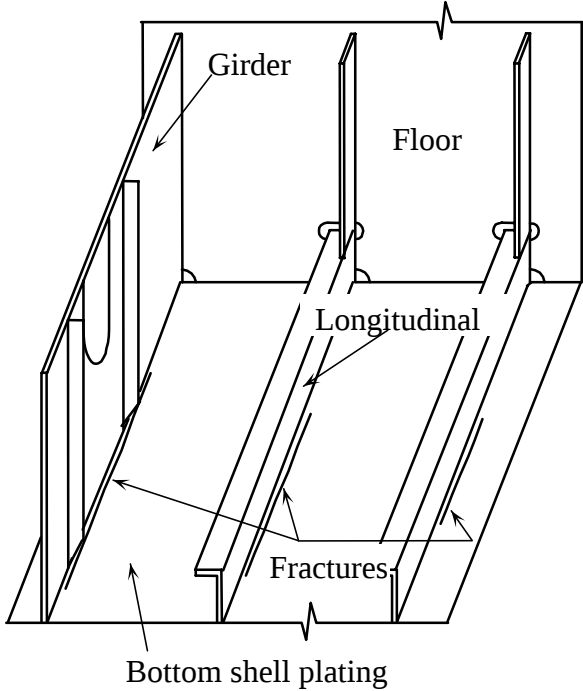
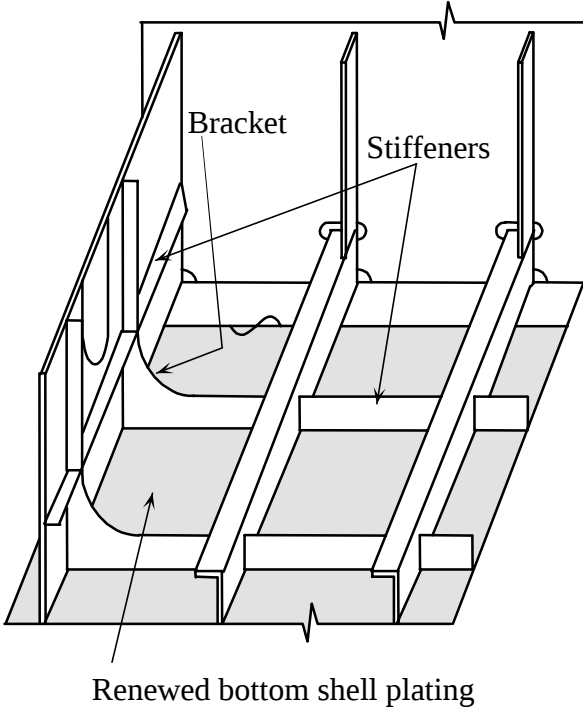
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No. 8	
Area 5	Double bottom tank structure including hopper		
Detail of damage		Fractures in bottom and inner bottom longitudinals in way of inner bottom and bulkhead stool boundaries	
Sketch of damage		Sketch of repair	
		 f :Where required the longitudinal to be cropped and part renewed	
Notes on possible cause of damage		Notes on repairs	
1. Damage can be caused by stress concentration leading to accelerated fatigue in this region.		1. If fractures are not extensive e.g. hairline fractures then these can be veed-out and welded. 2. If fracture extended to over one third of the depth of the longitudinal depth then crop and part renew.	

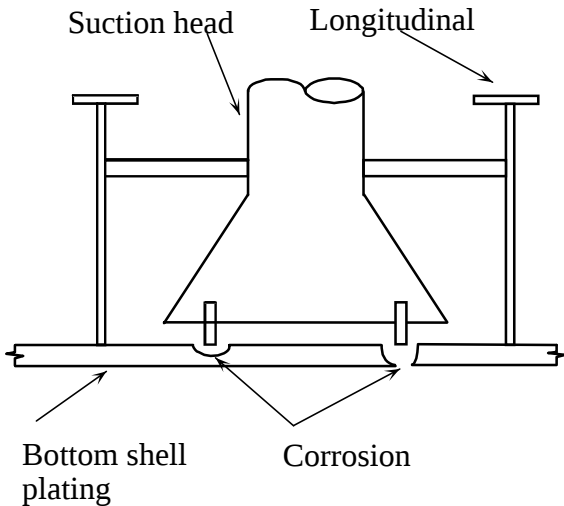
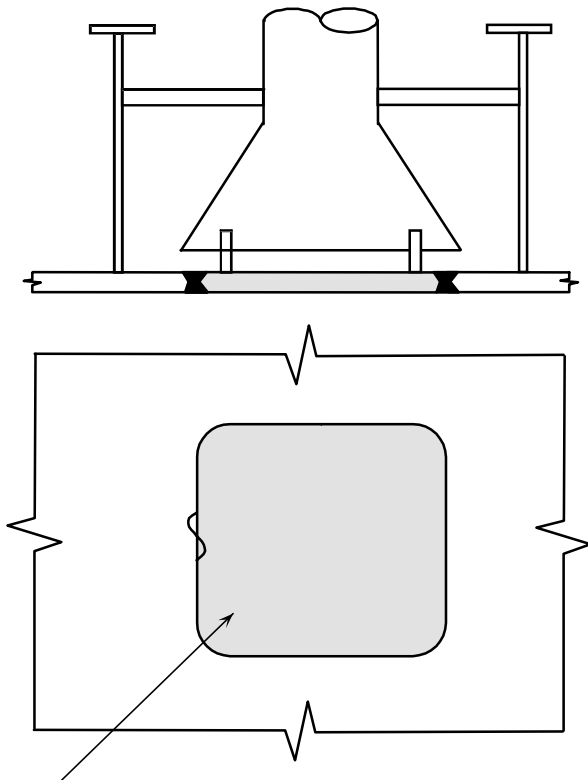
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 5	Double bottom tank structure including hopper	9	
Detail of damage		Fractures in longitudinal in way of bilge well	
Sketch of damage		Sketch of repair	
		 f: Where required the longitudinals to be cropped and part renewed	
Notes on possible cause of damage		Notes on repairs	
1. Damage can be caused by stress concentrations leading to accelerated fatigue in this region.		1. If fractures are not extensive e.g. hairline fractures then these can be veed-out and welded. 2. If the fracture extended to over one third of the depth of the longitudinal then crop and part renew.	

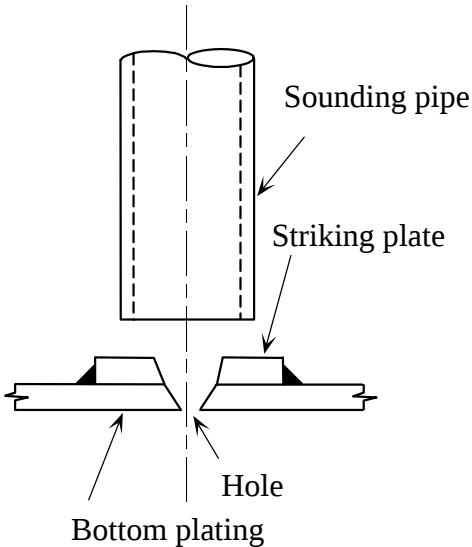
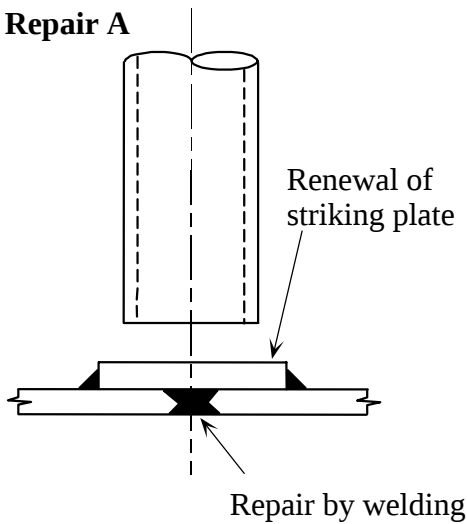
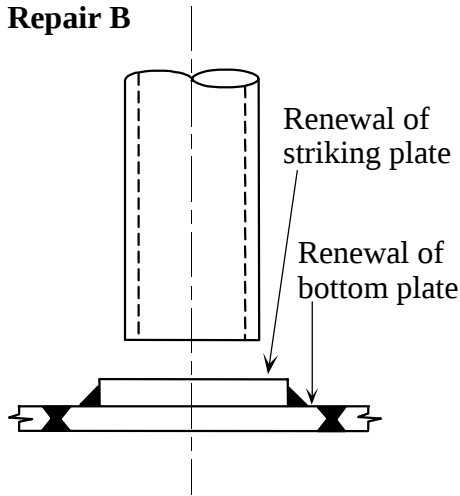
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 5	Double bottom tank structure including hopper	10	
Detail of damage		Buckling of transverse web	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage 1. Insufficient buckling strength of transverse web plating. 2. Corrosion of high stress area.		Notes on repairs 1. If the buckling occurred without significant corrosion, adequate reinforcement is to be carried out. 2. If the buckling occurred due to corrosion of high stress (shear stress) area, damaged area is to be cropped and part renewed. Adequate reinforcement and protective measures should be considered.	

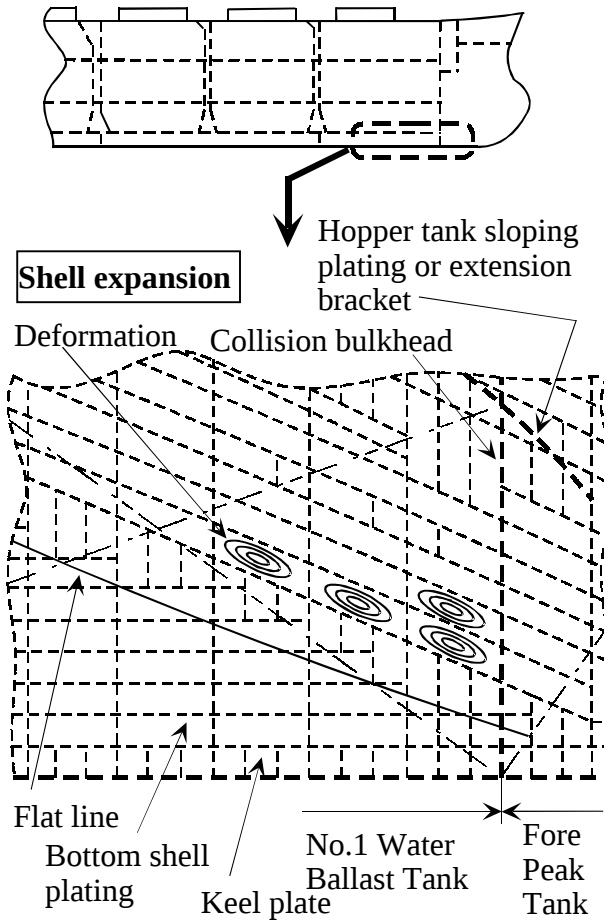
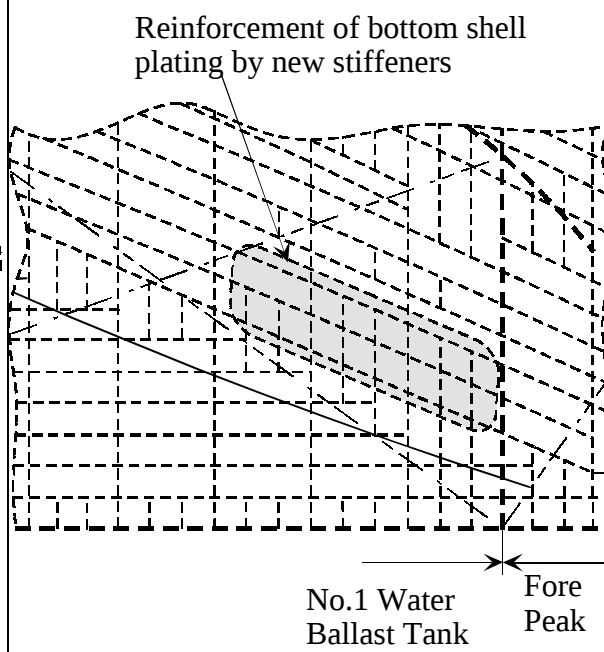
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No. 11	
Area 5	Double bottom tank structure including hopper		
Detail of damage		Fractures at weld connection of transverse brackets	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. General levels of corrosion and presence of stress concentration. 2. Misalignment of the brackets with adjoining structure e.g. frame brackets. 3. High shear stresses due to insufficient bracket. 4. Inadvertent overloading.		1. If the damage is caused by misalignment with the frame bracket above, the misalignment is to be rectified. 2. Replacement by a bracket of increased thickness or size should be considered.	

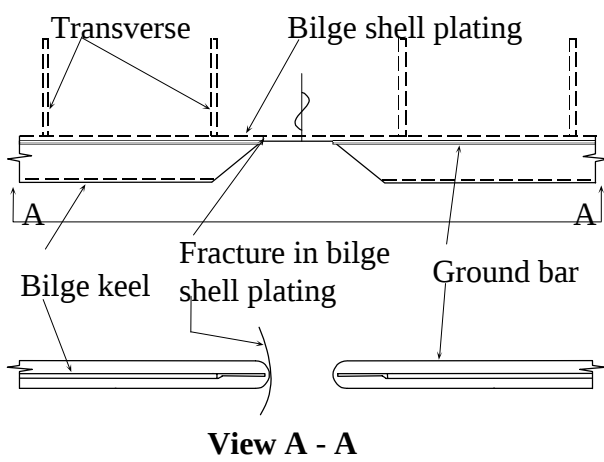
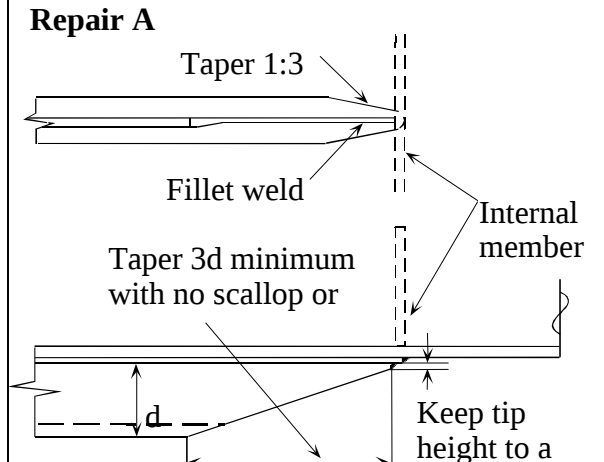
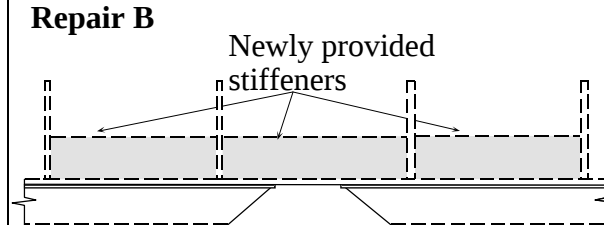
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No. 12	
Area 5	Double bottom tank structure including hopper		
Detail of damage		Fractures in bottom shell/side shell/hopper sloping plating at the corner drain hole/air hole in longitudinal	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Stress concentration and/or corrosion due to stress concentration at the corner of drain hole/air hole.		1. Fractured plating should be cropped and part renewed. 2. If fatigue life is to be improved, change of drain hole/air hole shape is to be considered.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 5	Double bottom tank structure including hopper	13	
Detail of damage		Fractures in bottom plating along side girder and/or bottom longitudinal	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Vibration.		1. Fractured bottom shell plating should be cropped and renewed. 2. Natural frequency of the panel should be changed, e.g. reinforcement by additional stiffener/bracket.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No. 14	
Area 5	Double bottom tank structure including hopper		
Detail of damage		Corrosion in bottom plating below suction head	
Sketch of damage		Sketch of repair	
		 1. Insert to have round corners 2. Non-destructive examination to be applied after welding based on the CCS rules	
Notes on possible cause of damage		Notes on repairs	
1. High flow rate associated with insufficient corrosion prevention system. 2. Galvanic action between dissimilar metals.		1. Affected plating should be cropped and part renewed. Thicker plate and suitable beveling should be considered. 2. If the corrosion is limited to a small area, i. e. pitting corrosion, repair by welding is acceptable.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No. 15	
Area 5	Double bottom tank structure including hopper		
Detail of damage		Corrosion in bottom plating below sounding pipe	
Sketch of damage 		Sketch of repair Repair A  Repair B 	
Notes on possible cause of damage 1. Accelerated corrosion of striking plate by the striking of the weight of the sounding tape.		Notes on repairs 1. Corroded bottom plating should be welded or partly cropped and renewed if considered necessary. 2. Corroded striking plate should be renewed.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region	Example No.	
Area 5	Double bottom structure including hopper	16	
Detail of damage		Deformation of forward bottom shell plate due to slamming	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Heavy weather. 2. Poor design for slamming. 3. Poor operation, i.e. negligence of heavy ballast.		1. Deformed bottom shell plating should be faired in place, or partly cropped and renewed if considered necessary. 2. Bottom shell plating should be reinforced by stiffeners.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 1	Cargo hold region		Example No.
Area 5	Double bottom structure including hopper		17
Detail of damage		Fractures in shell plating at the termination of bilge keel	
Sketch of damage  View A - A		Sketch of repair Repair A  Repair B 	
Notes on possible cause of damage 1. Poor design causing stress concentration.		Notes on repairs 1. Fractured plating is to be cropped and renewed. 2. Reduction of stress concentration of the bilge keel end should be considered. Repair A: Modification of the detail of end Repair B: New internal stiffeners Repair C: Continuous ground bar (in connection with Repair A) 3. Instead of Repair A or B continuous ground bar and bilge keel should be considered.	

Part 2 Fore and aft end regions

Contents

- Area 1 Fore end structure
- Area 2 Aft end structure
- Area 3 Stern frame, rudder arrangement and propeller shaft supports

Area 1 Fore End Structure

Contents

1 General

2 What to look for

- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 General comments on repair

- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

Figures and/or Photographs - Area 1

No.	Title
Figure 1	Fore end structure - Potential problem areas

Examples of structural detail failures and repairs - Area 1

Example No.	Title
1	Deformation of forecastle deck
2	Fractures in forecastle deck plating at bulwark
3	Fractures in side shell plating in way of chain locker
4	Deformation of side shell plating in way of forecastle space
5	Fracture and deformation of bow transverse web in way of cut-outs for side longitudinals
6	Fractures at toe of web frame bracket connection to stringer platform bracket

1 General

- 1.1 Due to the high humidity salt water environment, wastage of the internal structure in the fore peak ballast tank can be a major problem for many, and in particular ageing ships. Corrosion of structure may be accelerated where the tank is not coated or where the protective coating has not been properly maintained, and can lead to fractures of the internal structure and the tank boundaries.
- 1.2 Deformation can be caused by contact which can result in damage to the internal structure leading to fractures in the shell plating.
- 1.3 Fractures of internal structure in the fore peak tank and spaces can also result from wave impact load due to slamming and panting.
- 1.4 Forecastle structure is exposed to green water and can suffer damage such as deformation of deck structure, deformation and fracture of bulwarks and collapse of mast, etc.
- 1.5 Shell plating around anchor and hawse pipe may suffer corrosion, deformation and possible fracture due to movement of improperly stowed anchor.

2 What to look for

2.1 Material wastage

- 2.1.1 Wastage (and possible subsequent fractures) is more likely to be initiated at the locations as indicated in **Figure 1** and particular attention should be given to these areas. A close-up inspection should be carried out with selection of representative thickness measurements to determine the extent of corrosion.
- 2.1.2 Structure in chain locker is liable to have heavy corrosion due to mechanical damage of ~~to~~ the protective coating caused by the action of anchor chains. In some ships, especially smaller ships, the side shell plating may form boundaries of the chain locker and heavy corrosion may consequently result in holes in the side shell plating.

2.2 Deformations

- 2.2.1 Contact with quay sides and other objects can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and collision bulkhead. A close-up examination of the damaged area should be carried out to determine the extent of the damage.

2.3 Fractures

- 2.3.1 Fractures in the fore peak tank are normally found by close-up inspection of the internal structure.
- 2.3.2 Fractures are often found in transition region and reference should be made to **Part 1, Area 2** and **3**.

2.3.3 Fractures that extend through the thickness of the plating or through the boundary welds may be observed during pressure testing of tanks.

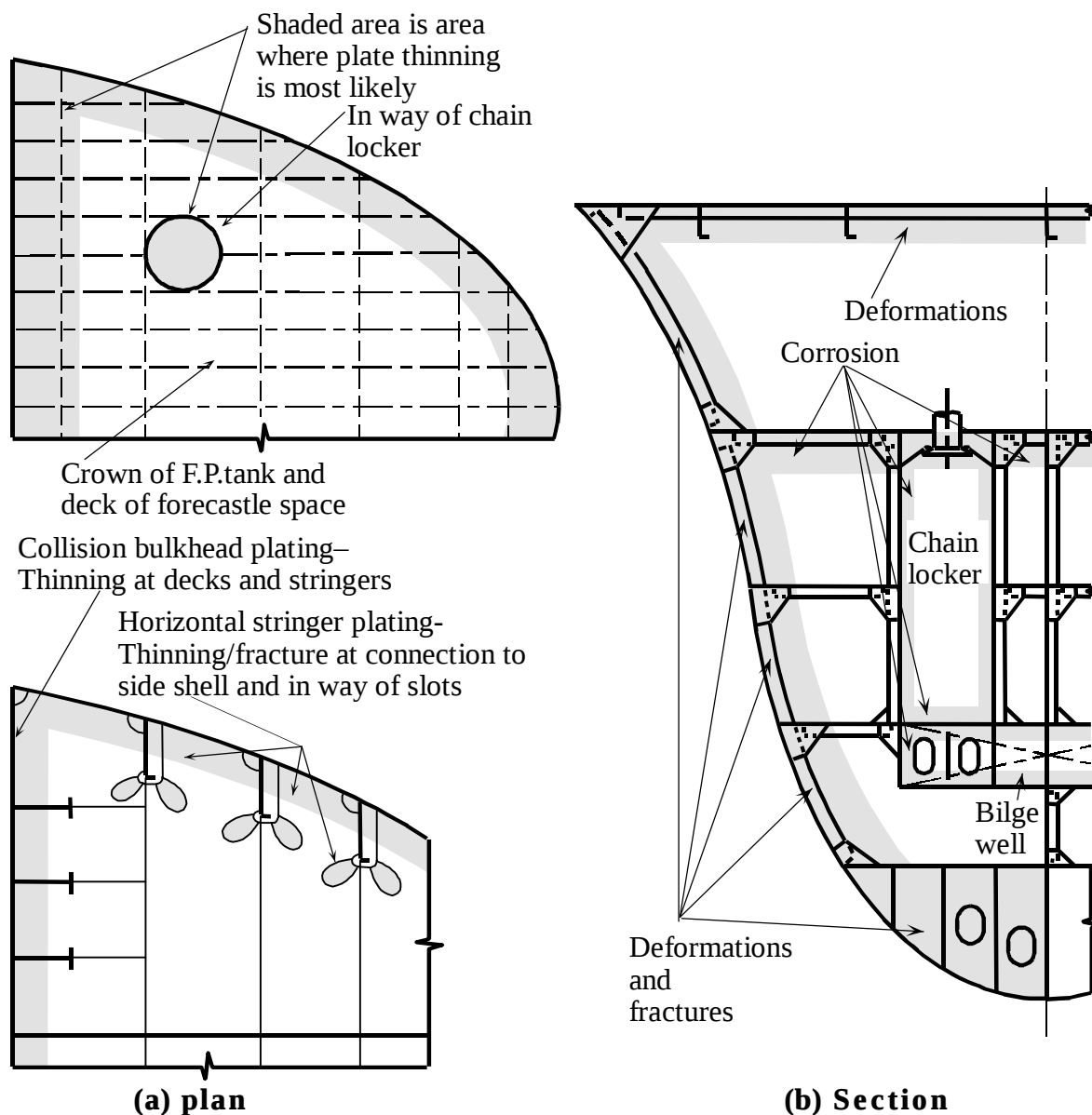


Fig 1 Fore end structure - Potential problem areas

3 General comments on repair

3.1 Material wastage

3.1.1 The extent of steel renewal required can be established based on representative thickness measurements. Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Repair work in tanks requires careful planning in terms of accessibility.

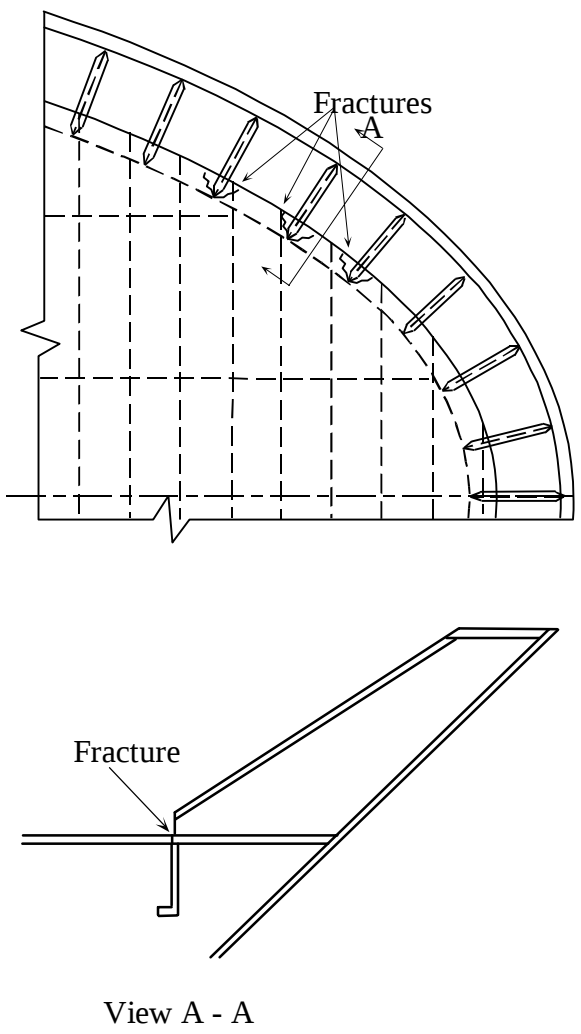
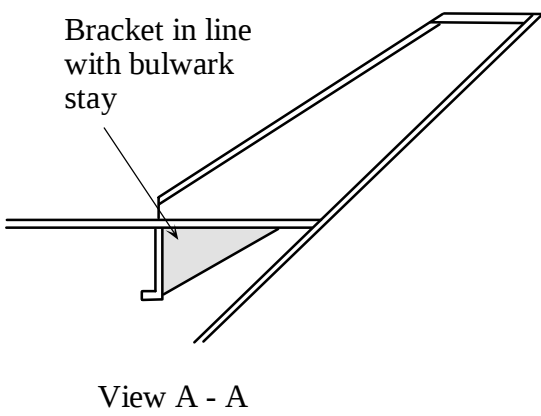
3.2 Deformations

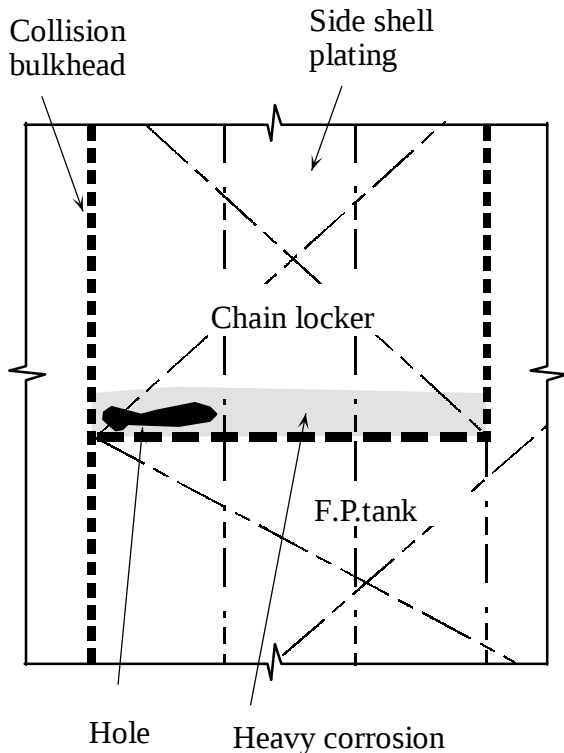
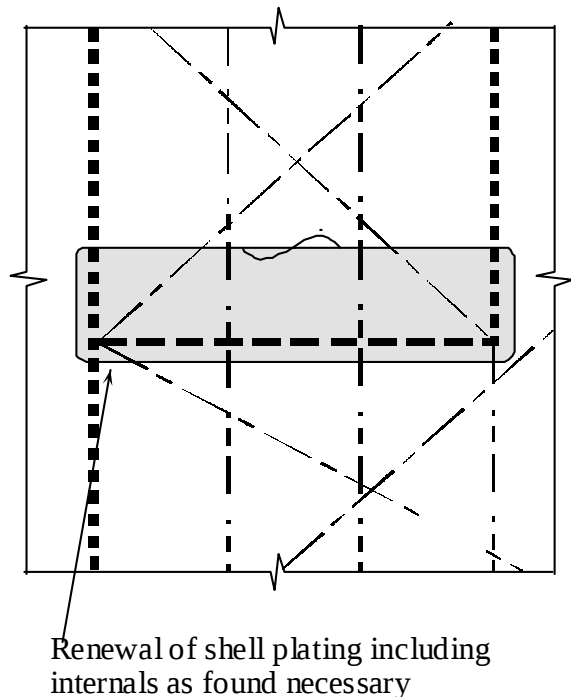
3.2.1 Deformed structure caused by contact should be cropped and part renewed or faired in place depending on the nature and extent of damage.

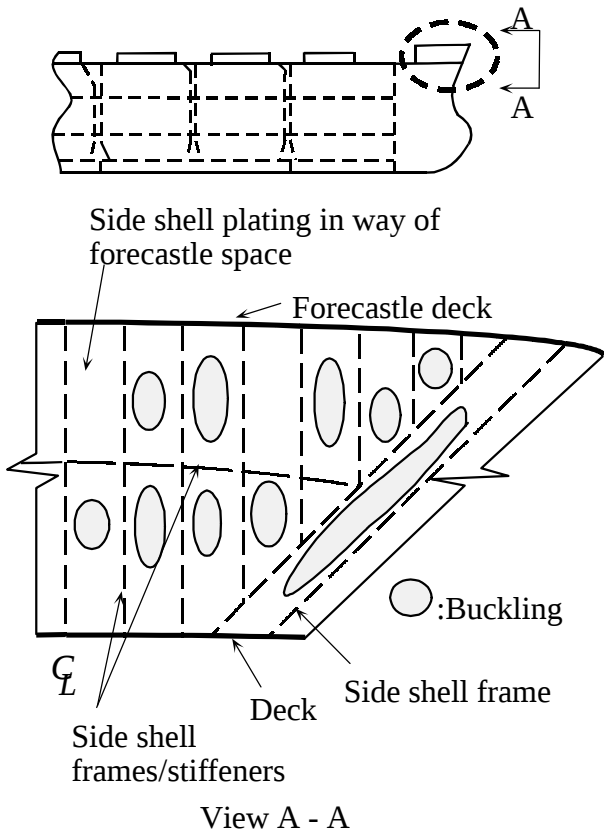
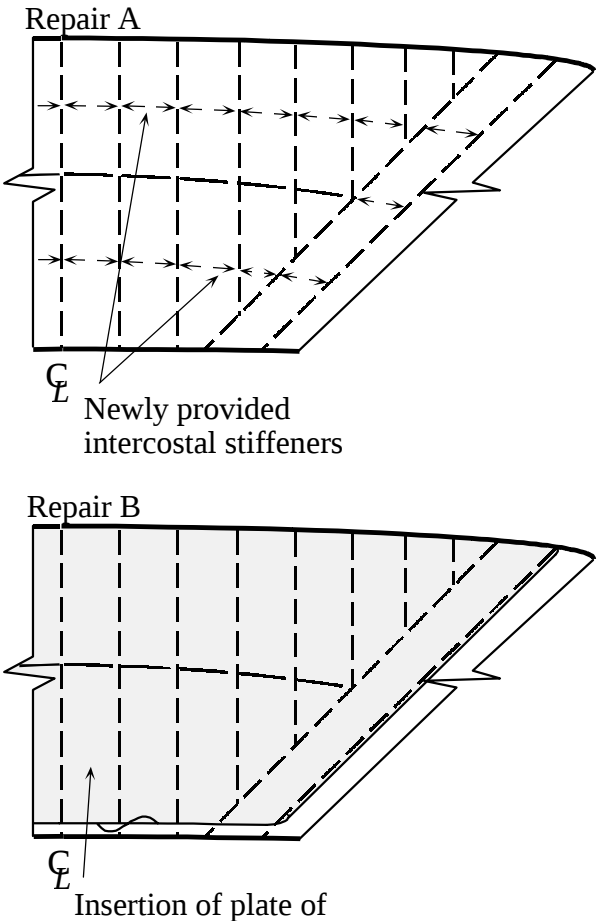
3.3 Fractures

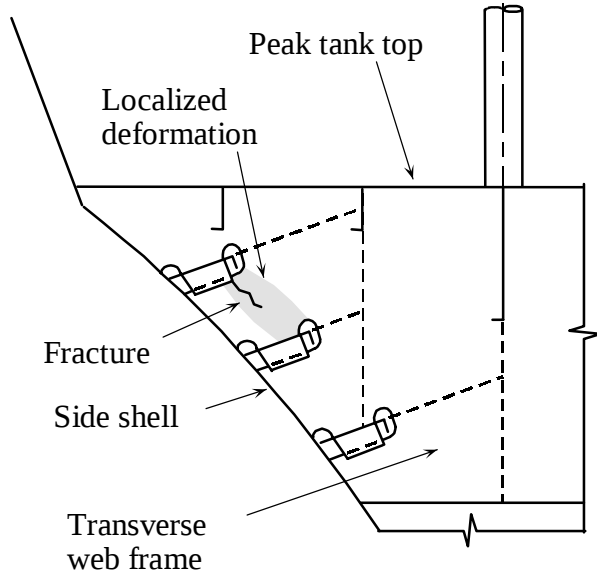
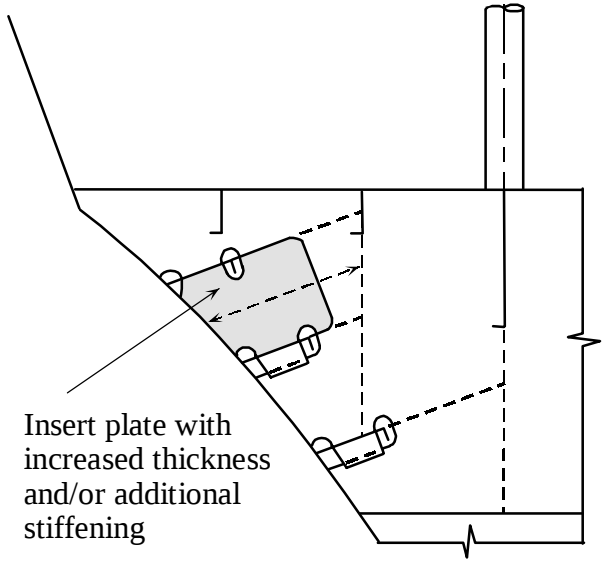
3.3.1 Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed. In the case of fractures caused by sea loads, increased thickness of plating and/or design modification to reduce stress concentrations should be considered (See **Examples 1, 2 and 6**).

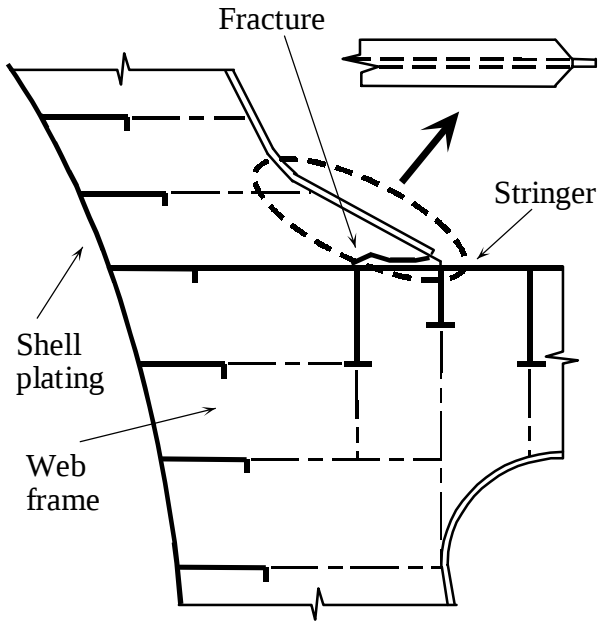
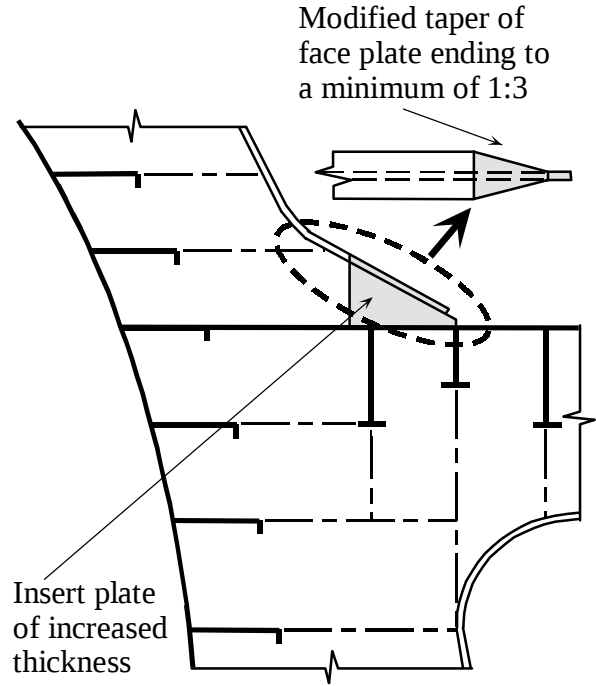
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 1	Fore end structure		1
Detail of damage		Deformation of forecastle deck	
Sketch of damage		Sketch of repair	
Notes on possible cause of damage		Notes on repairs	
1. Green sea on deck. 2. Insufficient strength.		1. Deformed structure should be cropped and renewed. 2. Additional stiffeners on web of beam should be considered for reinforcement.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 1	Fore end structure		2
Detail of damage		Fractures in forecastle deck plating at bulwark	
Sketch of damage		Sketch of repair	
 Fractures Fracture View A - A		 Bracket in line with bulwark stay View A - A	
Notes on possible cause of damage		Notes on repairs	
1. Bow flare effect in heavy weather. 2. Stress concentration due to poor design.		1. Fractured deck plating should be cropped and renewed. 2. Bracket in line with the bulwark stay to be fitted to reduce stress concentration.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 1	Fore end structure		3
Detail of damage		Fractures in side shell plating in way of chain locker	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Heavy corrosion in region where mud is accumulated.		Notes on repairs 1. Corroded plating should be cropped and renewed. 2. Protective coating should be applied.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 1	Fore end structure		4
Detail of damage		Deformation of side shell plating in way of forecastle space	
Sketch of damage		Sketch of repair	
 Side shell plating in way of forecastle space Forecastle deck Buckling Deck Side shell frame Side shell frames/stiffeners View A - A		 Repair A Newly provided intercostal stiffeners Repair B Insertion of plate of	
Notes on possible cause of damage		Notes on repairs	
1. Heavy weather. 2. Insufficient strength.		1. Deformed part should be cropped and part renewed. 2. Repair A Additional stiffeners between existing stiffeners should be considered. Repair B Insertion of plate of increased thickness with additional stiffeners.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 1	Fore end structure		5
Detail of damage		Fracture and deformation of bow transverse web in way of cut-outs for side longitudinals	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Localized material wastage in way of coating failure at cut-outs and sharp edges due to working of the structure. 2. Dynamic seaway loading in way of bow flare.		1. Sufficient panel strength to be provided to absorb the dynamic loads enhanced by bow flare shape.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 1	Fore end structure		6
Detail of damage		Fractures at toe of web frame bracket connection to stringer platform bracket	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Inadequate bracket forming the web frame connection to the stringer. 2. Localized material wastage in way of coating failure at bracket due to flexing of the structure. 3. Dynamic seaway loading in way of bow flare.		Notes on repairs 1. Adequate soft nose bracket endings with a face plate taper of at least 1 : 3 to be provided.	

Area 2 Aft end structure

Contents

1 General

2 What to look for

- 2.1 Material wastage
- 2.2 Deformations
- 2.3 Fractures

3 General comments on repair

- 3.1 Material wastage
- 3.2 Deformations
- 3.3 Fractures

Figures and/or Photographs - Area 2	
No.	Title
Figure 1	Aft end structure - Potential problem areas

Examples of structural detail failures and repairs - Area 2	
Example No.	Title
1	Fractures in longitudinal bulkhead in way of rudder trunk
2	Fractures at the connection of floors and girder / side brackets
3-a	Fractures in flat where rudder carrier is installed in steering gear room
3-b	Fractures in steering gear foundation brackets and deformed deck plate

1 General

- 1.1** Due to the high humidity salt water environment, wastage of the internal structure in the aft peak ballast tank can be a major problem for many, and in particular ageing, ships. Corrosion of structure may be accelerated where the tank is not coated or where the protective coating has not been properly maintained, and can lead to fractures of the internal structure and the tank boundaries.
- 1.1** Deformation can be caused by contact or wave impact action from astern (which can result in damage to the internal structure leading to fractures in the shell plating).
- 1.3** Fractures to the internal structure in the aft peak tank and spaces can also result from main engine and propeller excited vibration.

2 What to look for

2.1 Material wastage

- 2.1.1** Wastage (and possible subsequent fractures) is more likely to be initiated at in the locations as indicated in **Figure 1**. A close-up inspection should be carried out with selection of representative thickness measurements to determine the extent of corrosion. Particular attention should be given to bunker tank boundaries and spaces adjacent to heated engine room.

2.2 Deformations

- 2.2.1** Contact with quay sides and other objects can result in large deformations and fractures of the internal structure. This may affect the watertight integrity of the tank boundaries and bulkheads. A close-up examination of the deformed area should be carried out to determine the extent of the damage.

2.3 Fractures

- 2.3.1** Fractures in weld at floor connections and other locations in the aft peak tank and rudder trunk space can normally only be found by close-up inspection.
- 2.3.2** The structure supporting the rudder carrier may fracture and/or deform due to excessive load on the rudder. Bolts connecting the rudder carrier to the steering gear flat may also suffer damage under such load.

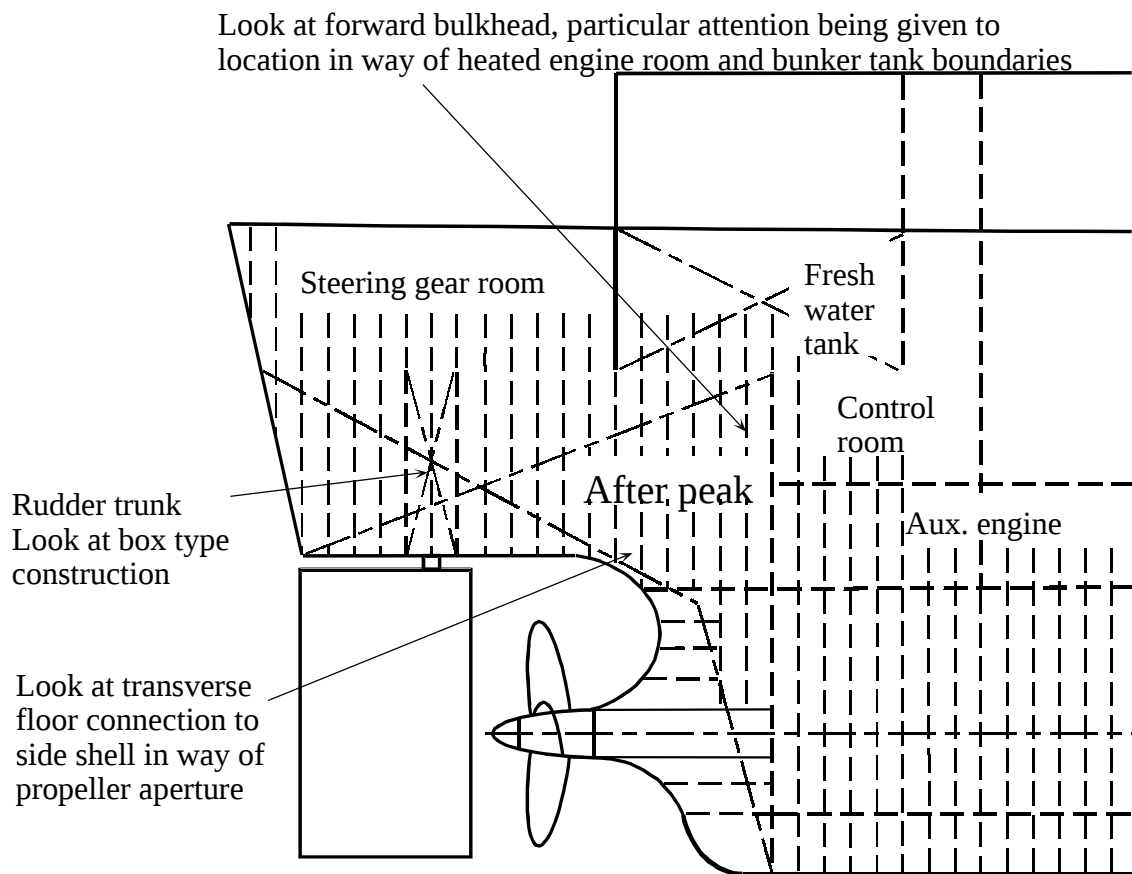


Figure 1 Aft end structure - Potential problem areas

3 General comments on repair

3.1 Material wastage

3.1.1 The extent of steel renewal required can be established based on representative thickness measurements. Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed. Repair work in tanks requires careful planning in terms of accessibility.

3.2 Deformations

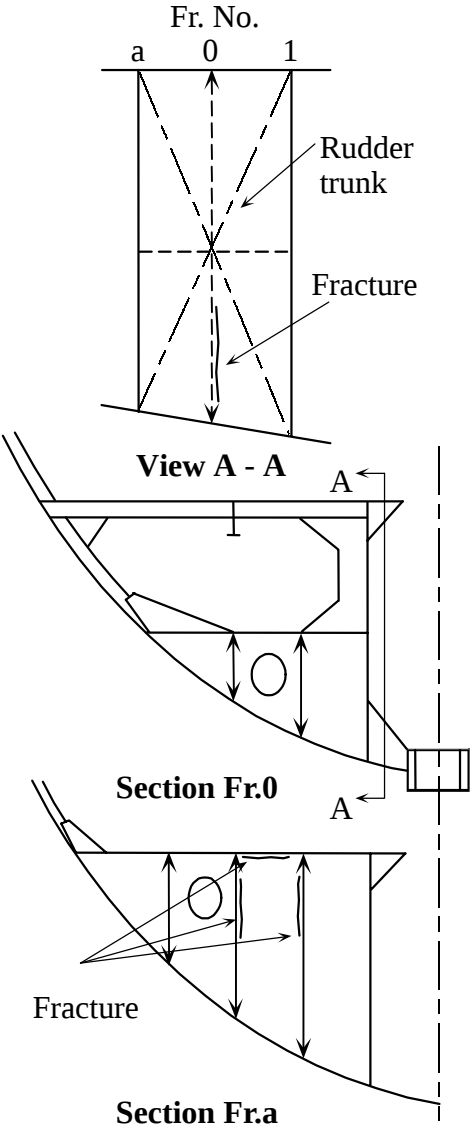
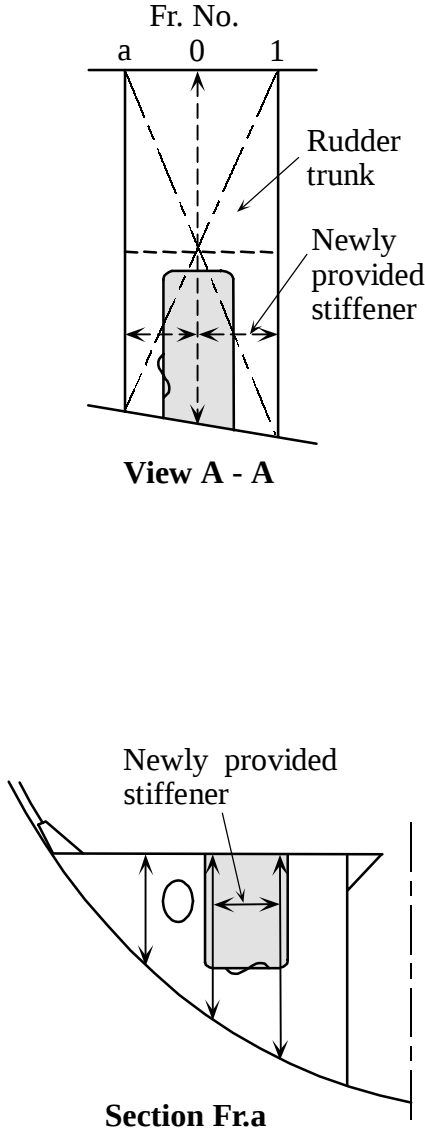
3.2.1 Deformed structure caused by contact should be cropped and part renewed or faired in place depending on the extent of damage.

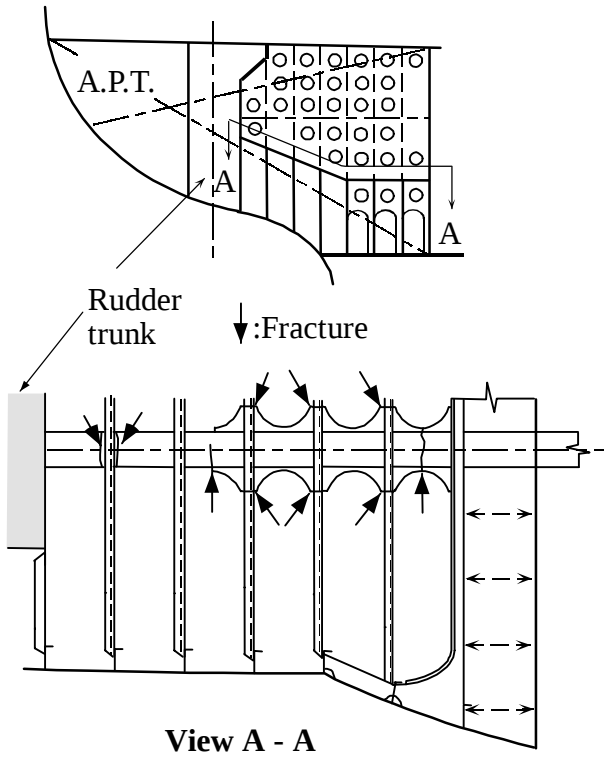
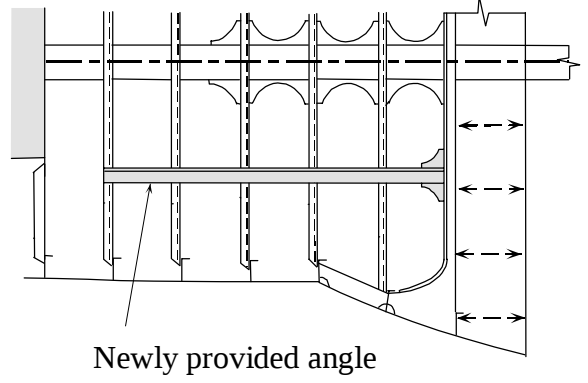
3.3 Fractures

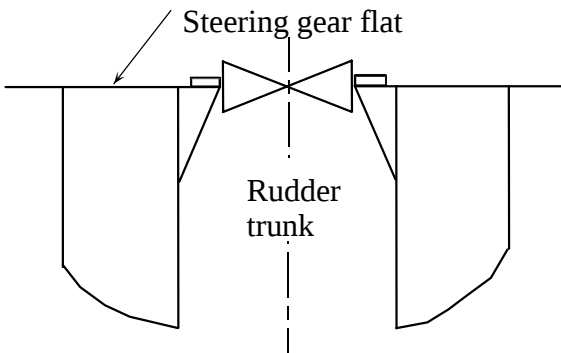
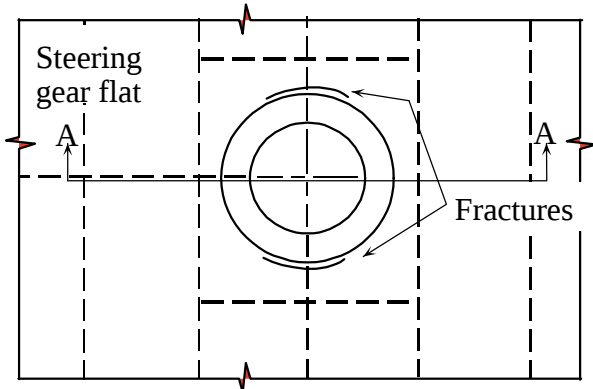
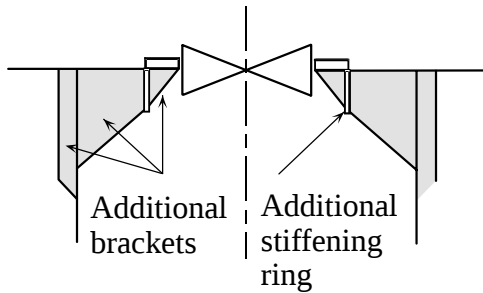
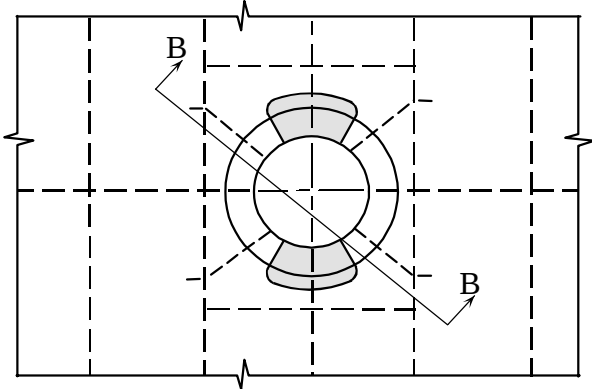
3.3.1 Fractures of a minor nature may be veed-out and rewelded. Where cracking is more extensive, the structure is to be cropped and renewed.

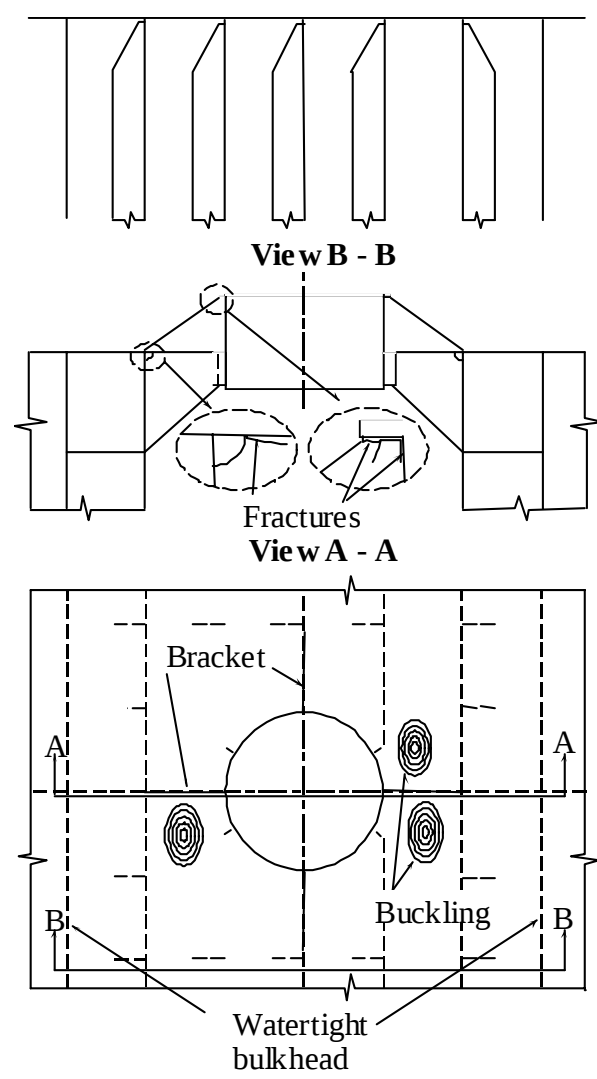
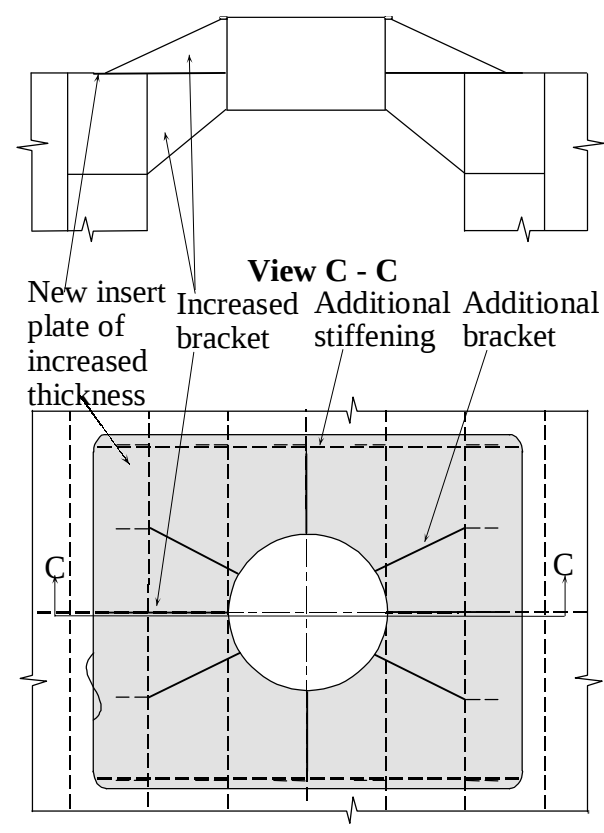
3.3.2 In order to prevent recurrence of damages suspected to be caused by main engine or propeller excited vibration, the cause of the vibration should be ascertained and additional reinforcements provided as found necessary (See **Examples 1 and 2**).

- 3.3.3** In the case of fractures caused by sea loads, increased thickness of plating and/or design modifications to reduce stress concentrations should be considered.
- 3.3.4** Fractured structure which supports rudder carrier is to be cropped, and renewed, and may have to be reinforced (See **Examples 3-a** and **3-b**).

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 2	Aft end structure		1
Detail of damage		Fractures in bulkhead in way of rudder trunk	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Vibration.		Notes on repairs 1. The fractured plating should be cropped and renewed. 2. Natural frequency of the plate between stiffeners should be changed, e.g. reinforcement by additional stiffeners.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 2	Aft end structure		2
Detail of damage		Fractures at the connection of floors and girders / side brackets	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Vibration.		Notes on repairs 1. The fractured plating should be cropped and renewed. 2. Natural frequency of the panel should be changed, e.g. reinforcement by additional strut.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 2	Aft end structure		3-a
Detail of damage		Fractures in flat where rudder carrier is installed in steering gear room	
Sketch of damage		Sketch of repair	
 Steering gear flat Rudder trunk View A - A  Steering gear flat Fractures		 Additional brackets Additional stiffening ring View B - B 	
Notes on possible cause of damage		Notes on repairs	
1. Inadequate design.		1. Fractured plating should be cropped and renewed.	
		2. Additional brackets and stiffening ring should be fitted for reinforcement.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 2	Aft end structure		3-b
Detail of damage		Fractures in steering gear foundation brackets and deformed deck plate	
Sketch of damage		Sketch of repair	
 View B - B Fractures View A - A Bracket Buckling Watertight bulkhead		 View C - C New insert plate of increased thickness Increased bracket Additional stiffening Additional bracket	
Notes on possible cause of damage		Notes on repairs	
1. Insufficient deck strengthening (missing base plate). 2. Insufficient strengthening of steering gear foundation. 3. Bolts of steering gear were not sufficiently pre-loaded.		1. New insert base plate of increased plate thickness. 2. Additional longitudinal stiffening at base plate edges. 3. Additional foundation brackets above and under deck (star configuration).	

Area 3 Stern frame, rudder arrangement and propeller shaft support

Contents

1 General

2 What to look for - Drydock inspection

- 2.1 Deformation
- 2.2 Fractures
- 2.3 Corrosion / Erosion / Abrasion

3 General comments on repair

- 3.1 Rudder stock and pintles
- 3.2 Plate structure
- 3.3 Abrasion of bush and sleeve
- 3.4 Assembling of rudders
- 3.5 Repair of propeller boss and stern tube

Figures and/or Photographs - Area 3	
No.	Title
Figure 1	Nomenclature for stern frame, rudder arrangement and propeller shaft support
Figure 2	Potential problem areas
Photograph 1	Fractured rudder
Figure 3	Rudder stock repair by welding
Diagram 1	Preheating temperature

Examples of structural detail failures and repairs - Area 3	
Example No.	Title
1	Fractures in rudder horn along bottom shell plating
2	Fractures in rudder stock
3	Fractures in connection of palm plate to rudder blade
4	Fractures in rudder plating of semi-spade rudder (short fractures with end located forward of the vertical web)
5	Fractures in rudder plating of semi-spade rudder extending beyond the vertical web
6	Fractures in rudder plating of semi-spade rudder in way of pintle cutout
7	Fractures in side shell plating at the connection to propeller boss
8	Fractures in stern tube at the connection to stern frame

1 General

- 1.1** The stern frame, possible strut bearing arrangement and connecting structures are exposed to propeller induced vibrations, which may lead to fatigue cracking in areas where stress concentrations occur.
- 1.2** The rudder and rudder horn are exposed to accelerated and fluctuating stream from the propeller, which may also lead to fatigue cracking in areas where stress concentrations occur.
- 1.3** In extreme weather conditions the rudder may suffer wave slamming forces causing deformations of rudder stock and rudder horn as well as of the rudder itself.
- 1.4** Rudder and rudder horn as well as struts (on shafting arrangement with strut bearings) may also come in contact with floating object such as timber-log or ice causing damages similar to those described in **1.3**.
- 1.5** Since different materials are used in adjacent compartments and structures, accelerated (galvanic) corrosion may occur if protective coating and/or sacrificial anodes are not maintained properly.
- 1.6** Pre-existing manufacturing internal defects in cast pieces may lead to fatigue cracking.
- 1.7** A summary of potential problem areas is shown in **Figure 2**.
- 1.8** A complete survey of the rudder arrangement is only possible in drydock. However, in some cases a survey including a damage survey can be carried out afloat by divers or with a trimmed ship.

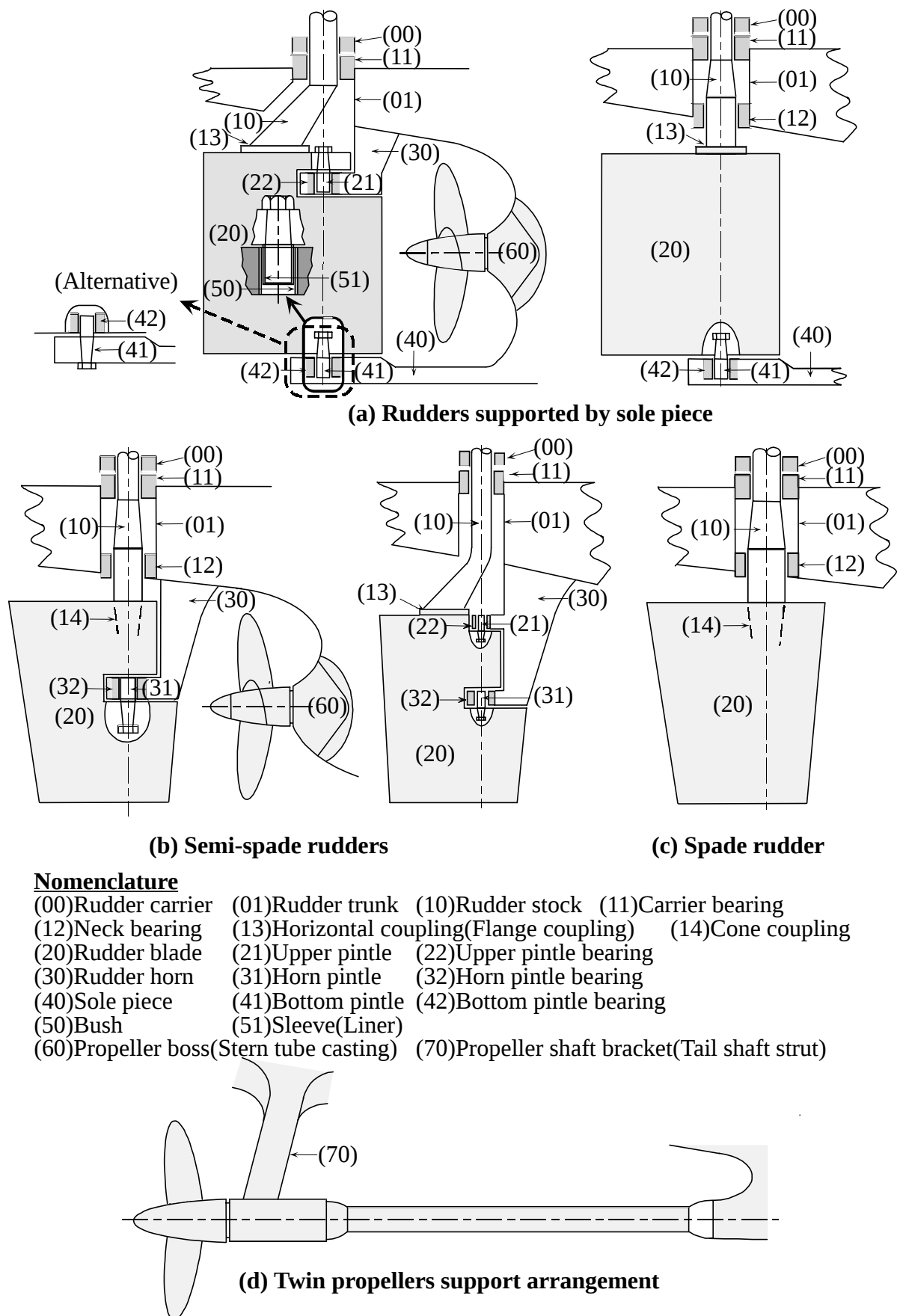
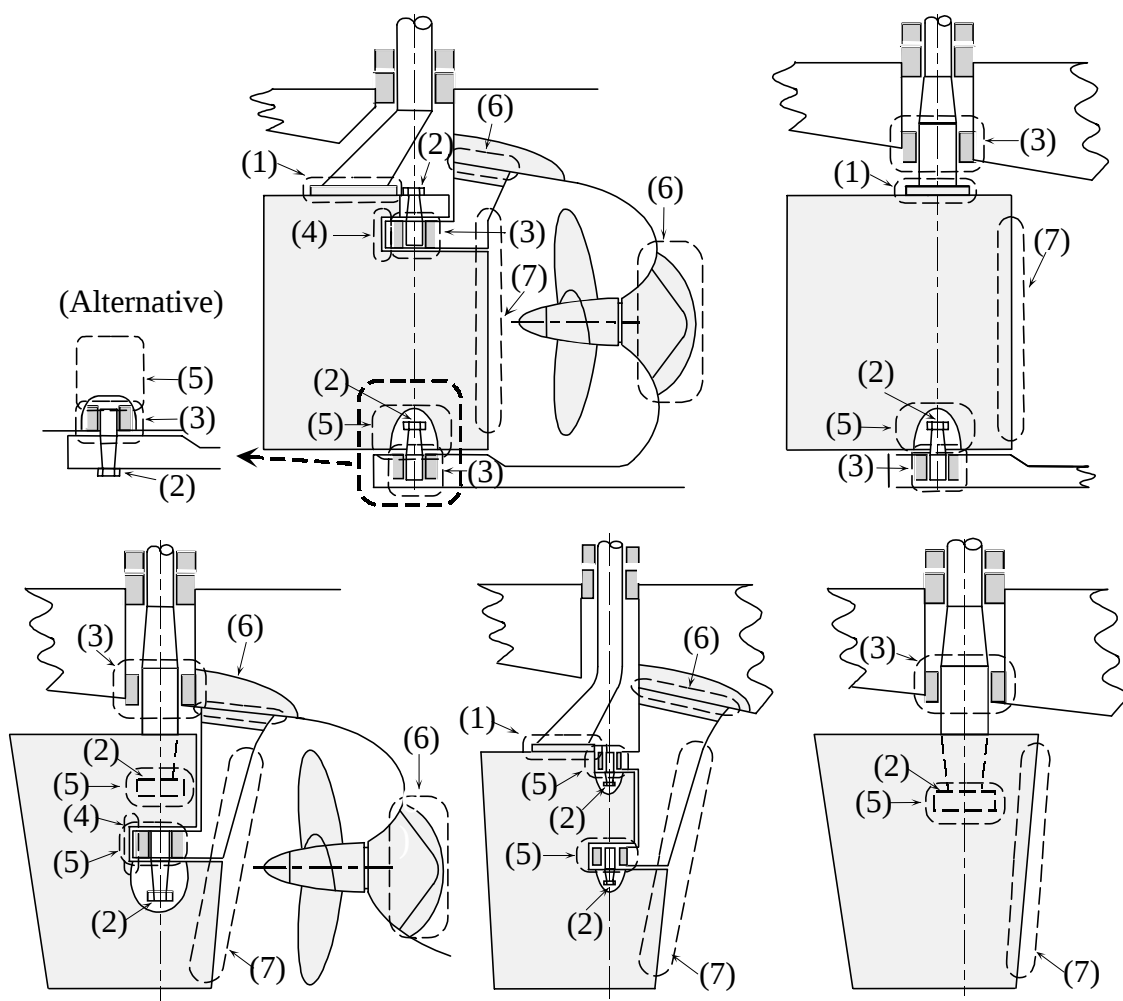


Figure 1 Nomenclature for stern frame, rudder arrangement and propeller shaft support



Damage to look for:

- (1) Fractures and loose coupling bolts
- (2) Loose nut
- (3) Wear (excessive bearing clearance)
- (4) Fractures in way of pintle cutout
- (5) Fractures in way of removable access plate
- (6) Fractures
- (7) Erosion

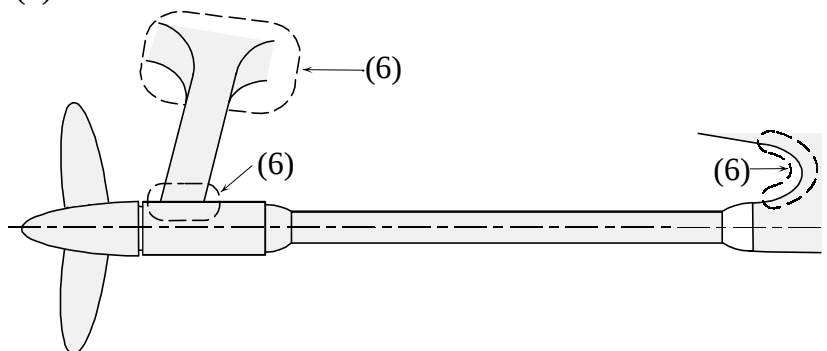


Figure 2 Potential problem areas

2 What to look for - Drydock inspection

2.1 Deformations

- 2.1.1 Rudder blade, rudder stock, rudder horn and propeller boss/brackets have to be checked for deformations.
- 2.1.2 Indications of deformation of rudder stock/rudder horn could be found by excessive clearance.
- 2.1.3 Possible twisting deformation or slipping of cone connection can be observed by the difference in angle between rudder and tiller.
- 2.1.4 If bending or twisting deformation is found, the rudder has to be dismantled for further inspection.

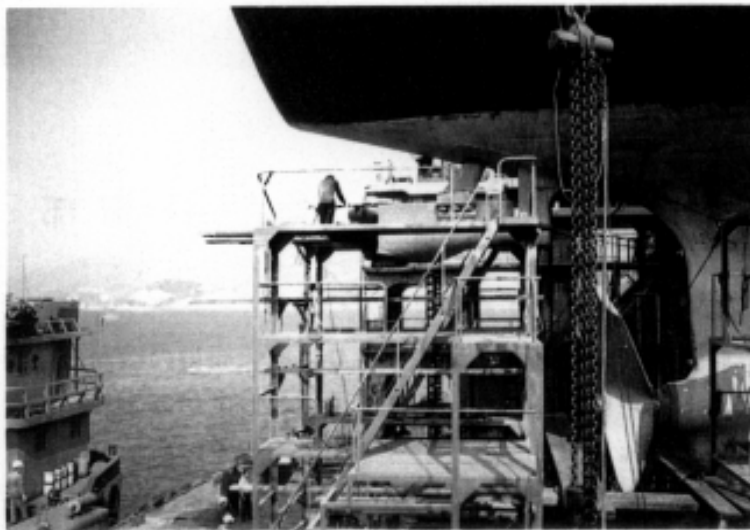
2.2 Fractures

- 2.2.1 Fractures in rudder plating should be looked for at slot welds, welds of removable part to the rudder blade, and welds of the access plate in case of vertical cone coupling between rudder blade and rudder stock and/or pintle. Such welds may have latent defects due to the limited applicable welding procedure. Serious fractures in rudder plating may cause loss of rudder.
- 2.2.2 Fractures should be looked for at weld connection between rudder horn, propeller boss and propeller shaft brackets, and stern frame.
- 2.2.3 Fractures should be looked for at the upper and lower corners in way of the pintle recess in case of semi-spade rudders. Typical fractures are shown in **Examples 3 to 5**.
- 2.2.4 Fractures should be looked for at the transition radius between rudder stock and horizontal coupling (palm) plate, and the connection between horizontal coupling plate and rudder blade in case of horizontal coupling. Typical fractures are shown in **Examples 1 and 2**. Fatigue fractures should be looked for at the palm plate itself in case of loosened or lost coupling bolts.
- 2.2.5 Fractures should be looked for in the rudder plating in way of the internal stiffening structures since (resonant) vibrations of the plating may have occurred.
- 2.2.6 If the rudder stock is deformed, fractures should be looked for in rudder stock by nondestructive examinations before commencing repair measures, in particular in and around the keyway, if any.

2.3 Corrosion/Erosion/Abrasion

- 2.3.1 Corrosion/erosion (such as deep pitting corrosion) should be looked for in rudder/rudder horn plating, especially in welds. In extreme cases the corrosion /erosion may cause a large fracture as shown in **Photograph**

1.



Photograph 1
Fractured rudder

2.3.2 The following should be looked for on rudder stock and pintle:

- Excessive clearance between sleeve and bush of rudder stock/pintle beyond the allowable limit specified by the Classification Society.
- Condition of sleeve. If the sleeve is loose, ingress of water may have caused corrosion.
- Deep pitting corrosion in the rudder stock and pintle adjacent to the stainless steel sleeve.
- Slipping of rudder stock cone coupling. For a vertical cone coupling with hydraulic pressure connection, sliding of the rudder stock cone in the cast piece may cause severe surface damages.
- Where a stainless steel liner/sleeve/cladding for the pintle/rudder stock is fitted into a stainless steel bush, an additional check should be made for crevice corrosion.

3 General comments on repair

3.1 Rudder stock and pintles

3.1.1 If rudder stock is twisted due to excessive forces such as contact or grounding and has no additional damages (fractures etc.) or other significant deformation, the stock usually can be used. The need for repair or heat treatment of the stock will depend on the amount of twist in the stock according to the requirements of the CCS. The keyway, if any, has to be milled in a new position.

3.1.2 Rudder stocks with bending deformations, not having any fractures may be repaired depending on the size of the deformation either by warm or by cold straightening in an approved workshop according to a procedure approved by the CCS. In case of warm straightening, as a guideline, the temperature should usually not exceed the heat treatment temperature of 530-580°C.

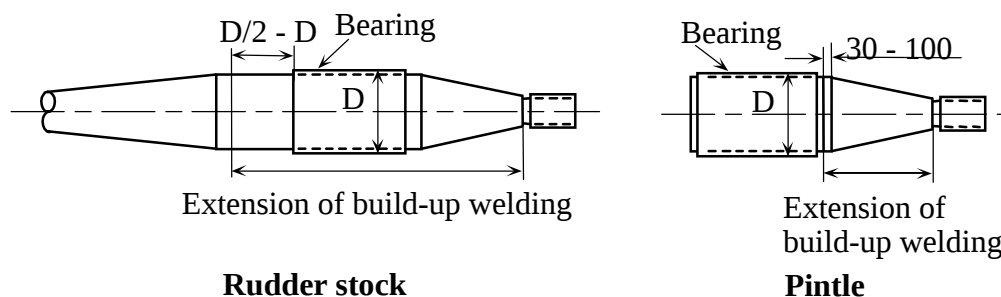
3.1.3 In case of fractures on a rudder stock with deformations, the stock may be used again depending on the nature and extent of the fractures. If a welding repair is considered acceptable, the fractures are to be removed by machining/grinding and the welding is to be based on an approved welding procedure together with post weld heat treatment as required by the CCS.

3.1.4 Rudder stocks and/or pintles may be repaired by welding replacing wasted material by similar weld material provided its chemical composition is suitable for welding, i.e. the carbon content must usually not exceed 0.25%. The welding procedures are to be identified in function of the carbon equivalent (Ceq). After removal of the wasted area (corrosion, scratches, etc.) by machining and/or grinding the build-up welding has to be carried out by an automatic spiral welding according to an approved welding procedure. The welding has to be extended over the area of large bending moments (rudder stocks). In special cases post weld heat treatment has to be carried out according to the requirements of the CCS. After final machining, a sufficient number of layers of welding material have to remain on the rudder stock/pintle. A summary of the most important steps and conditions of this repair is shown in the **Figure 3**.

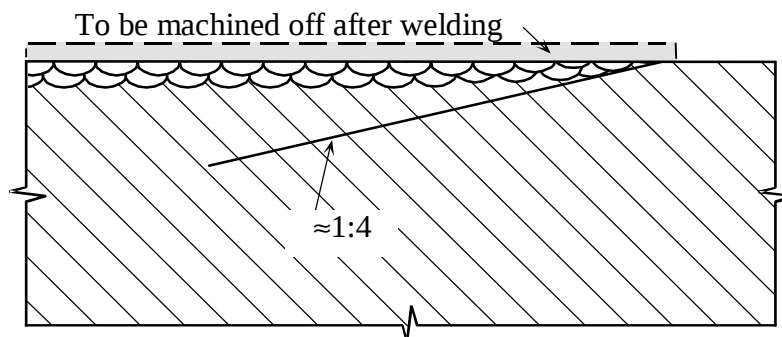
3.1.5 In case of rudder stocks with bending loads, fatigue fractures in way of the transition radius between the rudder stock and the horizontal coupling plate can not be repaired by local welding. A new rudder stock with a modified transition geometry has to be manufactured, as a rule (See **Example 1**). In exceptional cases a welding repair can be carried out based on an approved welding procedure. Measures have to be taken to avoid a coincidence of the metallurgical notch of the heat affected zone with the stress concentration in the radius' area. Additional surveys of the repair (including non-destructive fracture examination) have to be carried out in reduced intervals.

Replacing wasted material by similar ordinary weld material

- Removal of the wasted area by machining and/or grinding, non-destructive examination for fractures (magnetic particle inspection preferred)
- Build-up welding by automatic spiral welding (turning device) according to an approved welding procedure (weld process, preheating, welding consumables, etc.)
- Extension of build-up welding over the area of **large bending moments (shafts)** according to the sketch



- Sufficient number of weld layers to compensate removed material, at least one layer in excess (heat treatment of the remaining layer)
- Transition at the end of the build-up welding according to the following sketch



- Post weld heat treatment if required in special cases (never for stainless steel cladding on ordinary steel)
- Final machining, at least two layers of welding material have to remain on the rudder stock (See the above sketch)
- Non-destructive fracture examination

Figure 3 Rudder stock repair by welding

3.2 Plate structure

3.2.1 Fatigue fractures in welding seams (butt welds) caused by welding failures (lack of fusion) can be gouged out and rewelded with proper root penetration.

3.2.2 In case of fractures, probably caused by (resonant) vibration, vibration analysis of the rudder plating has to be performed, and design modifications have to be carried out in order to change the natural frequency of plate field.

3.2.3 Short fatigue fractures starting in the lower and/or upper corners of the pintle recess of semi-spade rudders that do not propagate into vertical or horizontal stiffening structures may be repaired by gouging out and welding. The procedure according to **Example 3** should be preferred.

In case of longer fatigue fractures starting in the lower and/or upper corners of the pintle recess of semi-spade rudders that propagate over a longer distance into the plating, thorough check of the internal structures has to be carried out. The fractured parts of the plating and of the internal structures, if necessary, have to be replaced by insert plates. A proper welding connection between the insert plate and the internal stiffening structure is very important (See **Examples 4** and **5**).

The area of the pintle recess corners has to be ground smooth after the repair. In many cases a modification of the radius, an increased thickness of plating and an enhanced steel quality may be necessary.

3.2.4 For the fractures at the connection between plating and cast pieces an adequate preheating is necessary. The preheating temperature is to be determined taking into account the following parameters:

- chemical composition (carbon equivalent C_{eq})
- thickness of the structure
- hydrogen content in the welding consumables
- heat input

3.2.5 As a guide, the preheating temperature can be obtained from **Diagram 1** using the plate thickness and carbon equivalent of the thicker structure.

3.2.6 All welding repairs are to be carried out using qualified / approved welding procedures.

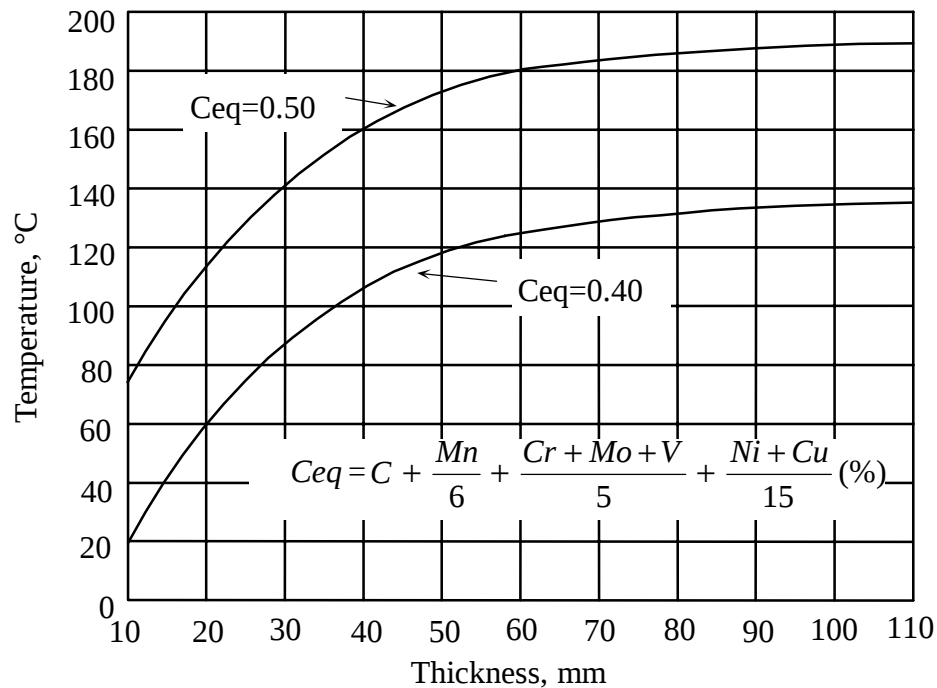


Diagram 1 Preheating temperature

3.3 Abrasion of bush and sleeve

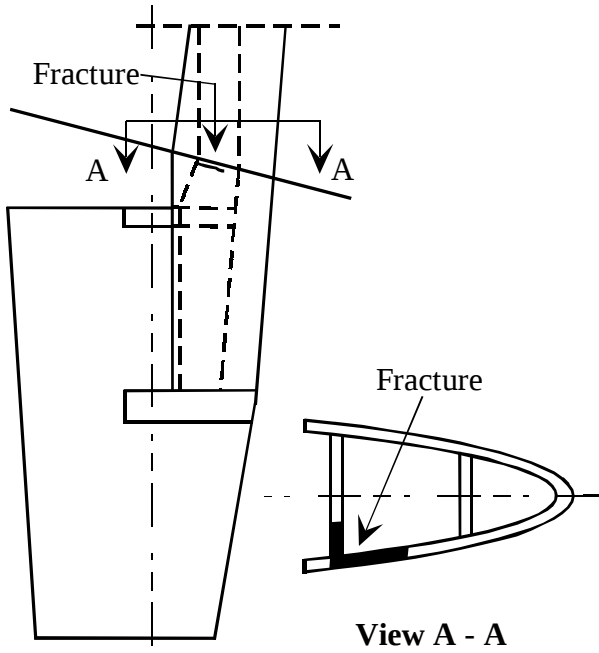
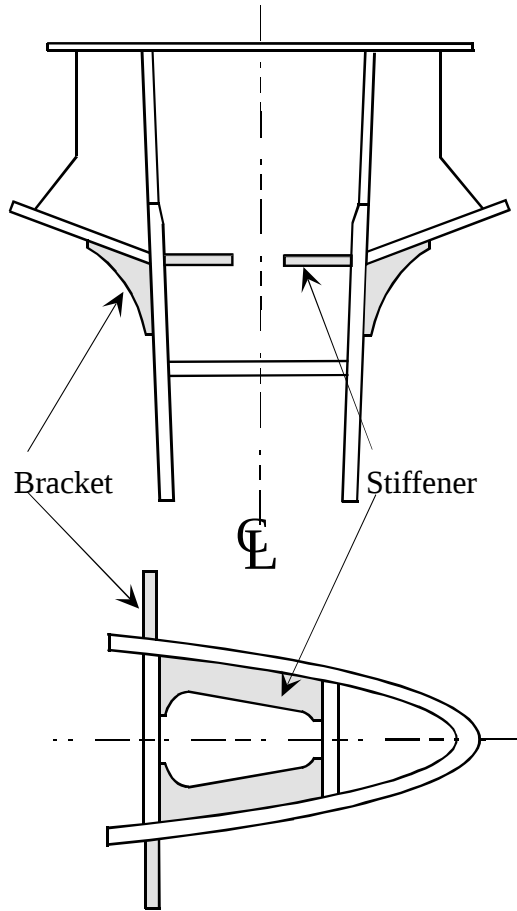
Abrasion rate depends on the features of the ship such as frequency of maneuvering. However, if excessive clearance is found within a short period, e.g. 5 years, alignment of the rudder arrangement and the matching of the materials for sleeve and bush should be examined together with the replacement of the bush.

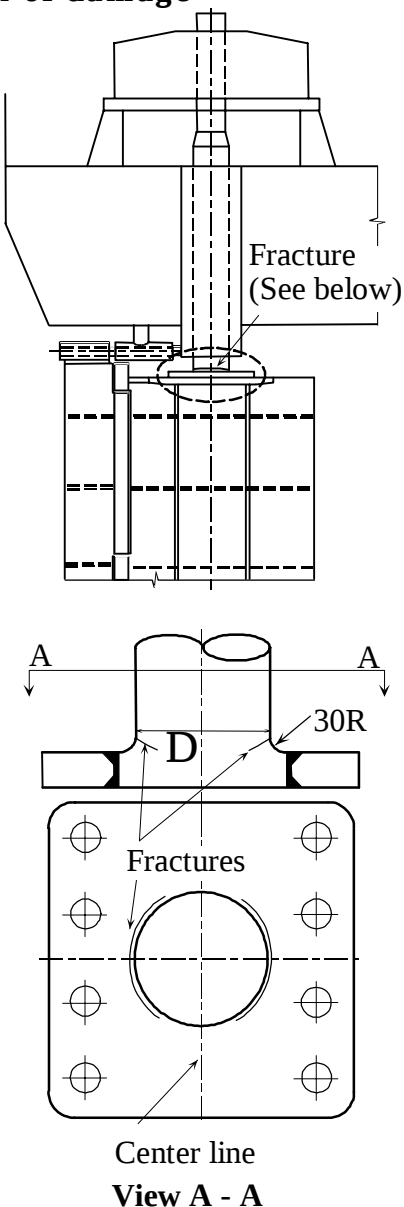
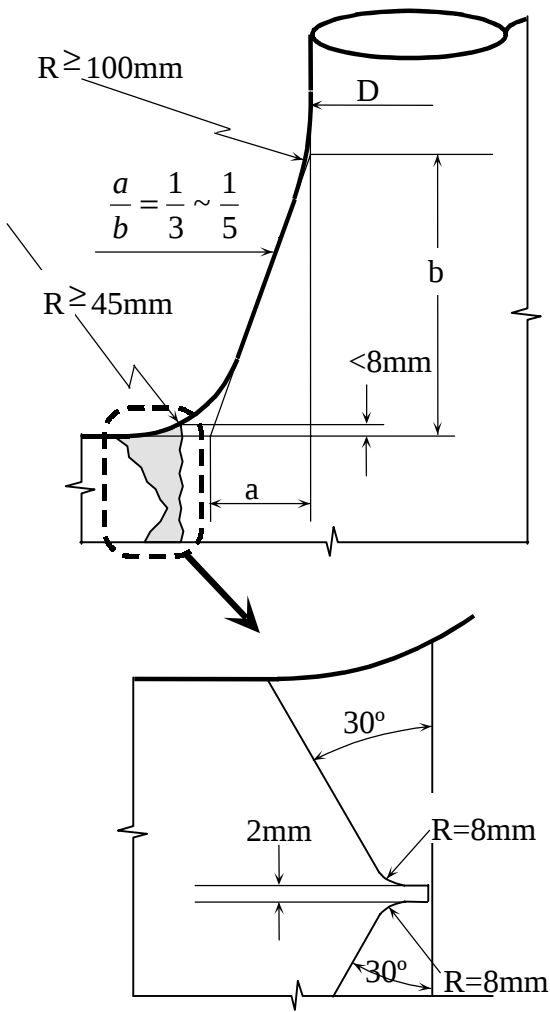
3.4 Assembling of rudders

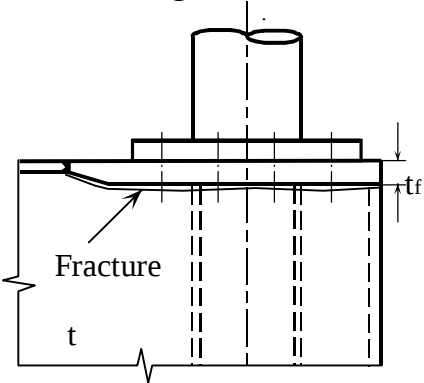
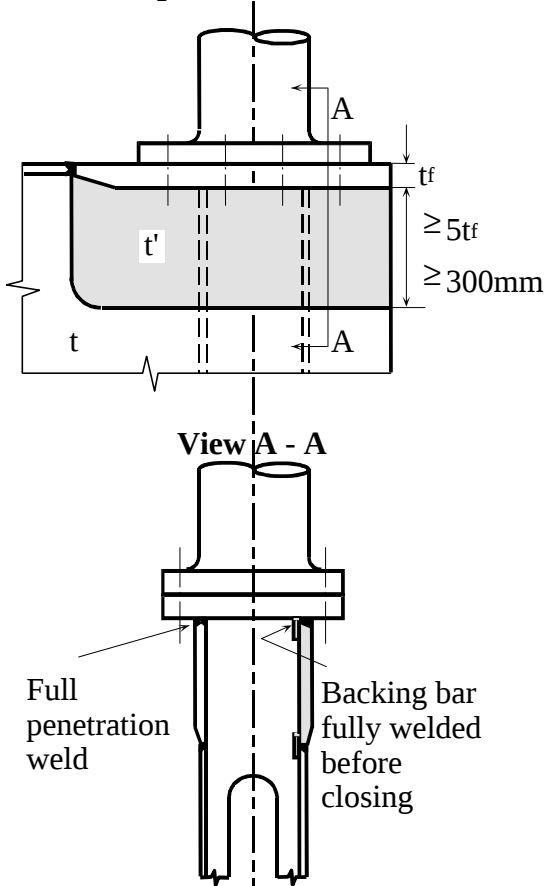
After mounting of all parts of the rudder, nuts of rudder stocks with vertical cone coupling plates and nuts of pintles are to be effectively secured. In case of horizontal couplings, bolts and their nuts are to be secured either against each other or both against the coupling plates.

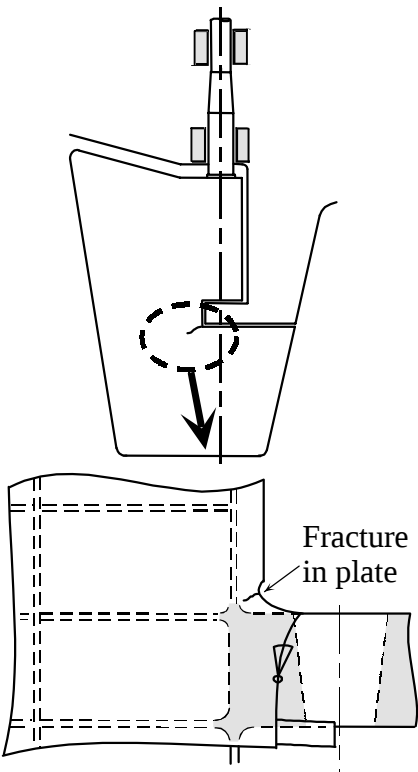
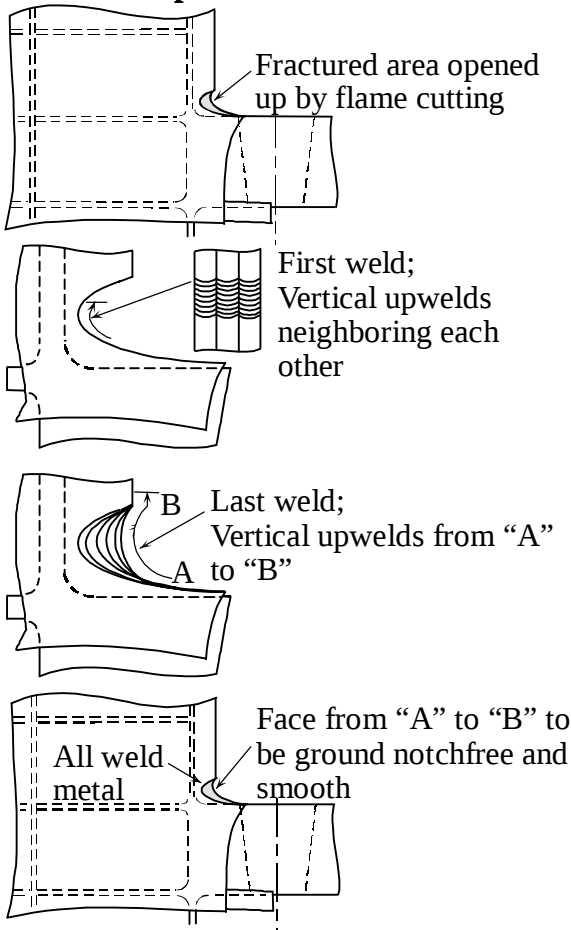
3.5 Propeller boss and stern tube

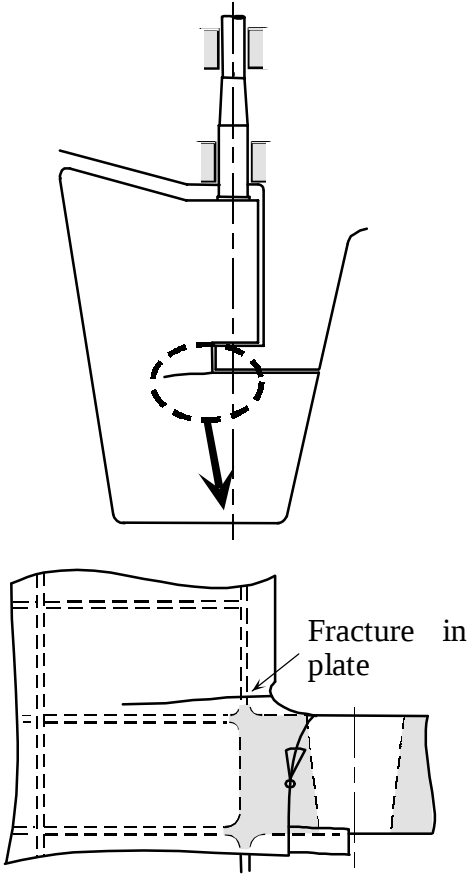
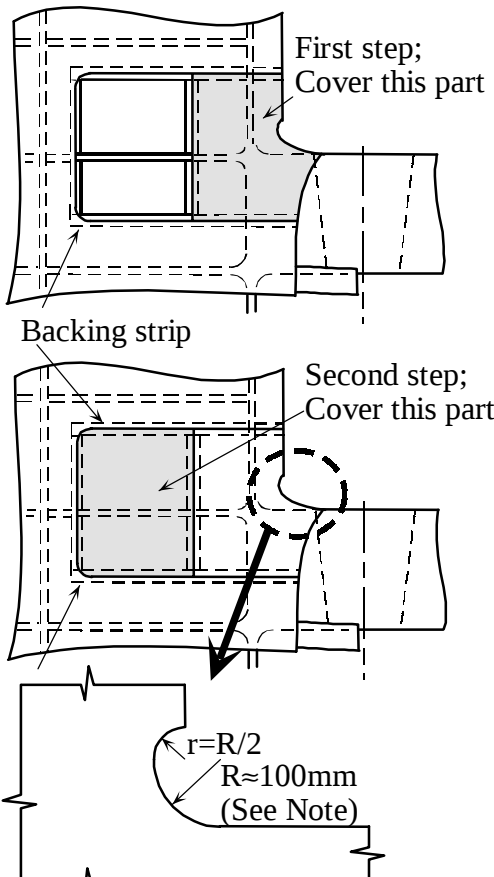
Repair examples for propeller boss and stern tube are shown in **Examples 7 and 8**. Regarding the welding reference is made to **3.1.4, 3.2.4 and 3.2.5**.

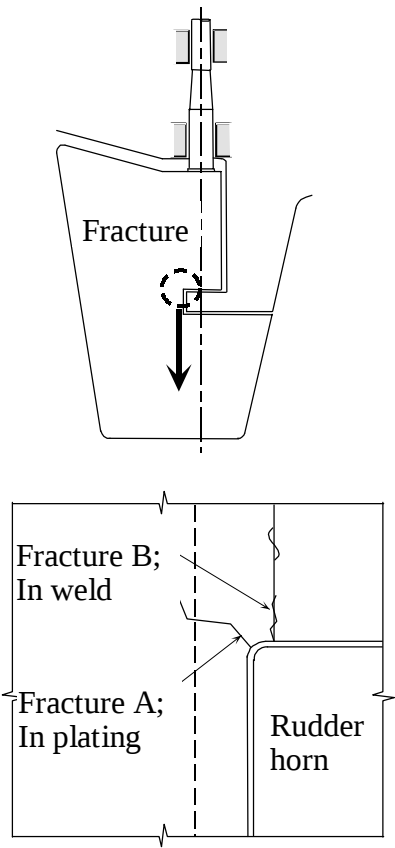
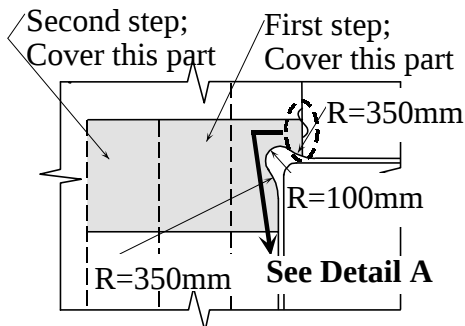
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support		1
Detail of damage		Fractures in rudder horn along bottom shell plating	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Insufficient strength due to poor design.		Notes on repairs 1. Fractured plating to be veed-out and rewelded. 2. Fractured plating to be cropped and renewed if considered necessary. 3. Reinforcement should be considered if considered necessary.	

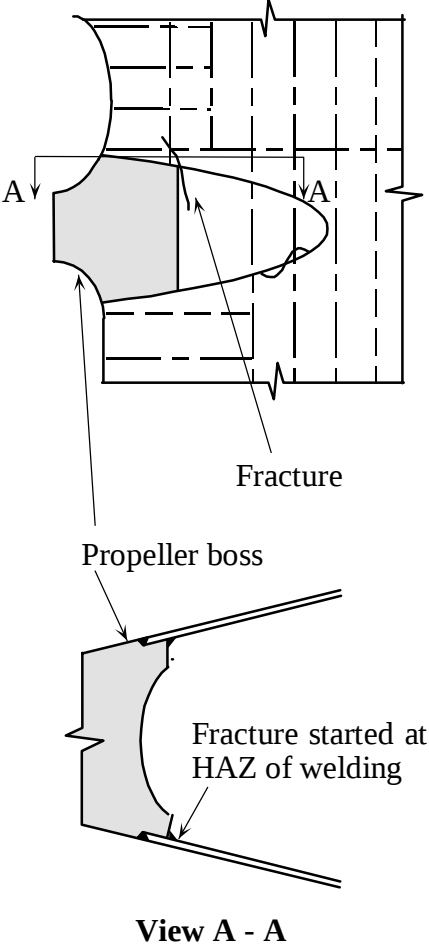
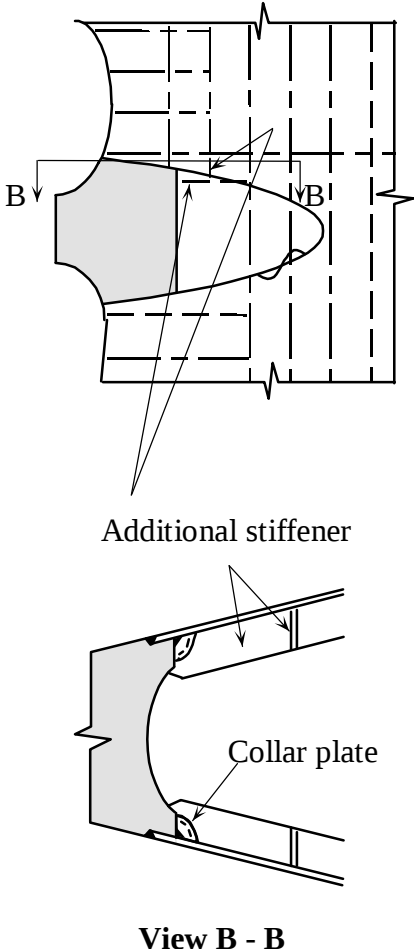
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.	
Area 3	Stern frame, rudder arrangement and propeller shaft support	2	
Detail of damage		Fractures in rudder stock	
Sketch of damage		Sketch of repair	
 Fracture (See below) Center line View A - A		 $R \geq 100\text{mm}$ $\frac{a}{b} = \frac{1}{3} \sim \frac{1}{5}$ $R \geq 45\text{mm}$ $< 8\text{mm}$ a b D 30° 2mm $R=8\text{mm}$ $R=8\text{mm}$	
Notes on possible cause of damage		Notes on repairs	
1. Inadequate design for stress concentration in rudder stock.		1. Modification of detail design of rudder stock to reduce the stress concentration.	

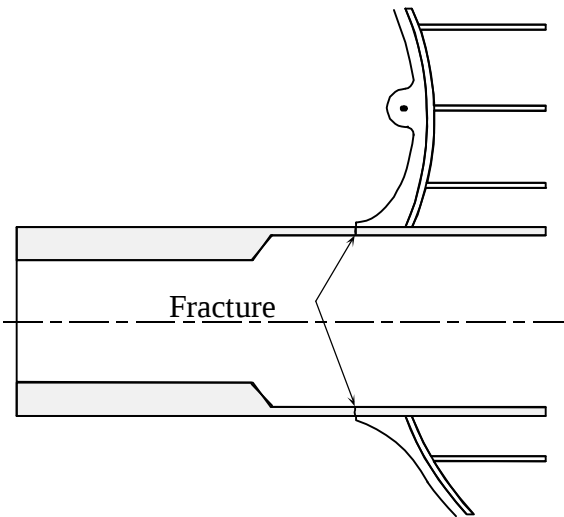
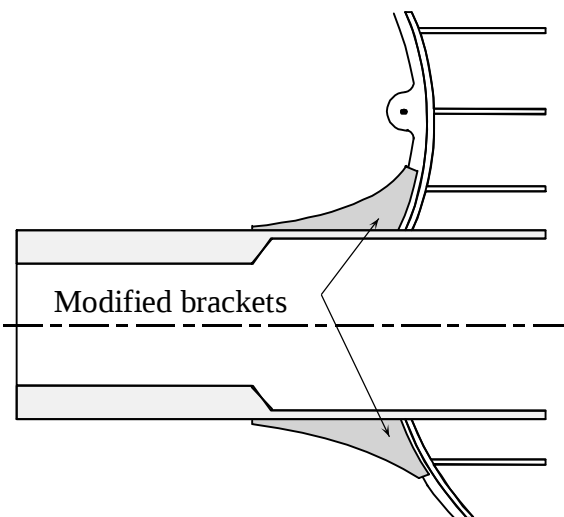
BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.	
Area 3	Stern frame, rudder arrangement and propeller shaft support	3	
Detail of damage		Fractures in connection of palm plate to rudder blade	
Sketch of damage		Sketch of repair	
		 View A - A Full penetration weld Backing bar fully welded before closing t = plate thickness, mm tf = actual flange thickness, mm $t = \frac{tf}{3} + 5$, mm, where $tf \leq 50$ mm $t = 3\sqrt{tf}$, mm, where $tf \geq 50$ mm	
Notes on possible cause of damage		Notes on repairs	
1. Inadequate connection between palm plate and rudder blade plating (insufficient plating thickness and/or insufficient fillet weld).		1. Modification of detail design of the connection by increasing the plate thickness and full penetration welding.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions	Example No.	
Area 3	Stern frame, rudder arrangement and propeller shaft support	4	
Detail of damage		Fractures in rudder plating of semi-spade rudder (short fracture with end located forward of the vertical web)	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Stress concentration due to inadequate local design and/or fabrication notches in way of the butt weld between cast piece and plating.		1. Grooving-out and welding of the fracture is not always adequate (metallurgical notch in way of a high stressed area). 2. In the proposed repair procedure the metallurgical notches are shifted into a zone exposed to lower stresses. 3. After welding a modification of the radius according to the proposal in Example 5 is to be carried out. 4. In case of very small crack it can be ground off by increasing the radius.	

GENERAL CARGO SHIPS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support		5
Detail of damage		Fractures in rudder plating of semi-spade rudder extending beyond the vertical web	
Sketch of damage		Sketch of repair	
 Fracture in plate		 First step; Cover this part Backing strip Second step; Cover this part $r = R/2$ $R \approx 100\text{mm}$ (See Note) Note: R should be considered according to local detail	
Notes on possible cause of damage		Notes on repairs	
1. Stress concentration due to inadequate local design and/or fabrication notches in way of the butt weld between cast piece and plating.		1. Fractured plating is to be cut-out. 2. Internal structures are to be checked. 3. Cut-out is to be closed by an insert plating according to the sketch (welding only from one side is demonstrated). 4. Modification of the radius. 5. In case of a new cast piece, connection with the plating is to be shifted outside the high stress area.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support		6
Detail of damage		Fractures in rudder plating of semi-spade rudder in way of pintle cutout	
Sketch of damage  The sketch shows a side view of a semi-spade rudder with a fracture in the plating indicated by a dashed circle and an arrow. Below it, a detail view shows a vertical weld joint with a fracture labeled 'Fracture B; In weld' and a horizontal fracture labeled 'Fracture A; In plating' near the 'Rudder horn'.		Sketch of repair  The repair sketch shows two steps: 'First step; Cover this part' and 'Second step; Cover this part'. It includes radii $R=350\text{mm}$ and $R=100\text{mm}$, and a reference to 'See Detail A'. Below the steps, a note states: 'Note: 1. R should be considered according to local detail 2. New contour should be ground smooth'. A detail view labeled 'View B - B' shows the repair with 'Rudder plating', 'Backing strip', and areas 'To be ground' and 'To be cut'.	
Notes on possible cause of damage 1. Inadequate design for stress concentration in way of pintle bearing (Fracture A). 2. Imperfection in welding seam (Fracture B).		Notes on repairs 1. Fractured part to be cropped off. 2. Repair by two insert plates of modified, stress releasing contour. For the vertical seam no backing strip is used 100mm off contour, welding from both sides, to be ground after welding. 3. Variant (See Detail A): Repair as mentioned under 2 with the use of backing strip for the complete vertical seam. After welding backing strip partly removed by grinding.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support		7
Detail of damage		Fractures in side shell plating at the connection to propeller boss	
Sketch of damage		Sketch of repair	
 Fracture Propeller boss Fracture started at HAZ of welding View A - A		 Additional stiffener Collar plate View B - B	
Notes on possible cause of damage		Notes on repairs	
1. Fatigue fracture due to vibration.		1. Fractured side shell plating is to be cropped and part renewed. 2. Additional stiffeners are to be provided. 3. Collar plate is to be provided.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 2	Fore and aft end regions		Example No.
Area 3	Stern frame, rudder arrangement and propeller shaft support		8
Detail of damage		Fractures in stern tube at the connection to stern frame	
Sketch of damage		Sketch of repair	
			
Notes on possible cause of damage		Notes on repairs	
1. Fatigue fracture due to vibration.		1. Fractured tube is to be veed-out and welded from both sides. 2. Brackets are to be replaced by modified brackets with soft transition.	

Part 3 Machinery and accommodation spaces

Contents

- Area 1 Engine room structure
- Area 2 Accommodation structure

Area 1 Engine room structure

Contents

1 General

2 What to look for - Engine room inspection

- 2.1 Material wastage
- 2.2 Fractures

3 What to look for - Tank inspection

- 3.1 Material wastage
- 3.2 Fractures

4 General comments on repair

- 4.1 Material wastage
- 4.2 Fractures

Examples of structural detail failures and repairs - Area 1	
Example No.	Title
1	Fractures in brackets at main engine foundation
2	Corrosion in bottom plating under sounding pipe in way of bilge storage tank
3	Corrosion in bottom plating under inlet/suction pipe in way of bilge storage tank

1 General

The engine room structure is categorized as follows:

- Boundary structure which consists of upper deck, bulkhead, inner bottom plating, funnel, etc.
- Deep tank structure
- Double bottom tank structure

The boundary structure can generally be inspected routinely and therefore any damages found can usually be easily rectified. Deep tank and double bottom structures, owing to access difficulties, generally cannot be inspected routinely. Damage of these structures is usually only found during dry docking or when a leakage is in evidence.

2 What to look for - Engine room inspection

2.1 Material wastage

- 2.1.1** Tank top plating, shell plating and bulkhead plating adjacent to the tank top plating may suffer severe corrosion caused by leakage or lack of maintenance of sea water lines.
- 2.1.2** Bilge well should be cleaned and inspected carefully for heavy pitting corrosion caused by sea water leakage at gland packing or maintenance operation of machinery.
- 2.1.3** Part of the funnel forming the boundary structure often suffer severe corrosion which may impair fire fighting in engine room and weathertightness.

3 What to look for - Tank inspection

3.1 Material wastage

- 3.1.1** The environment in bilge tanks, where mixture of oily residue and seawater is accumulated, is more corrosive when compared to other double bottom tanks. Severe corrosion may result in holes in the bottom plating, especially under sounding pipe. Pitting corrosion caused by seawater entered from air pipe is seldom found in cofferdam spaces.

3.2 Fractures

- 3.2.1** In general, deep tanks for fresh water or fuel oil are located in engine room. The structure in these tanks often sustains fractures due to vibration. Fracture of double bottom structure in engine room is seldom found due to its high structural rigidity.

4 General comments on repair

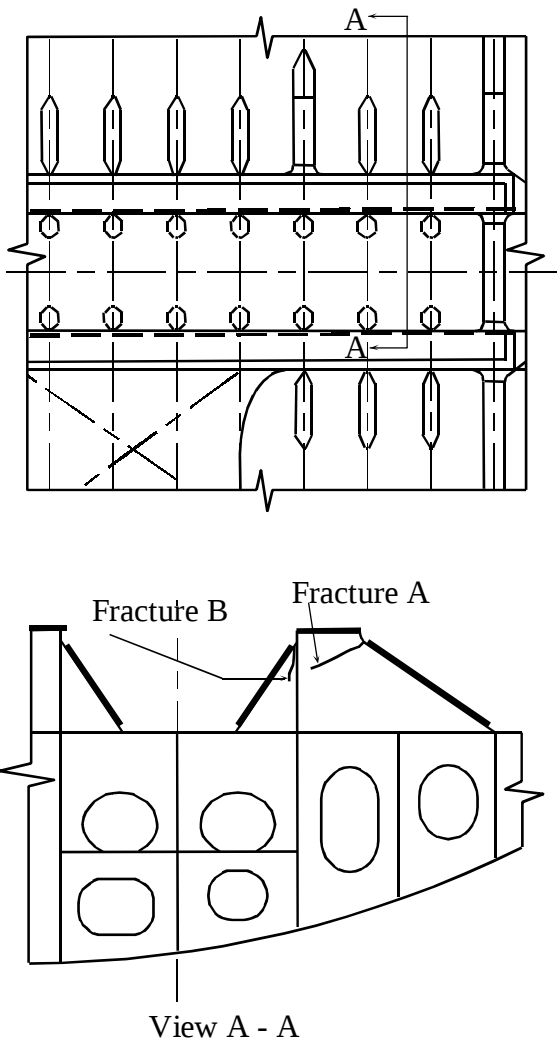
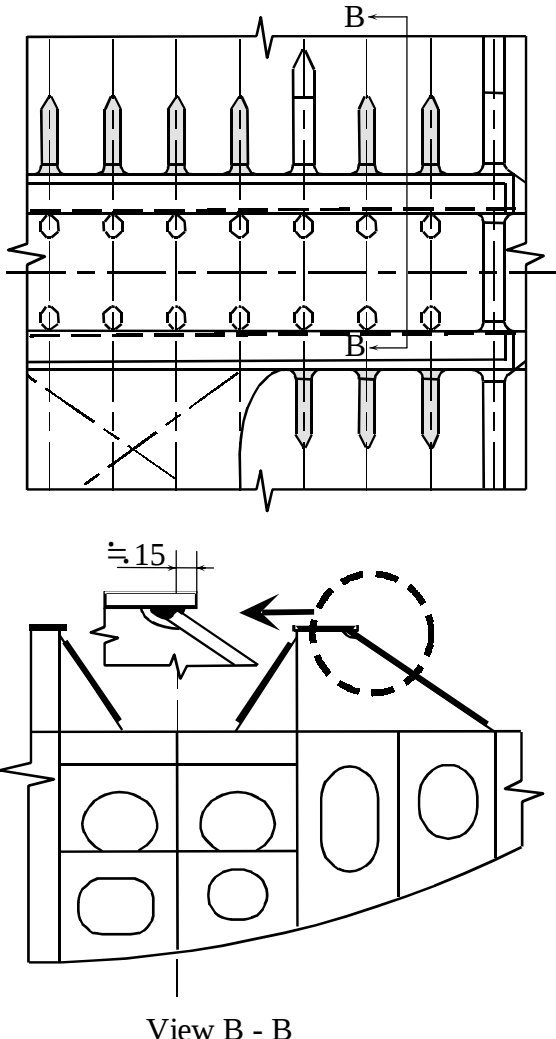
4.1 Material wastage

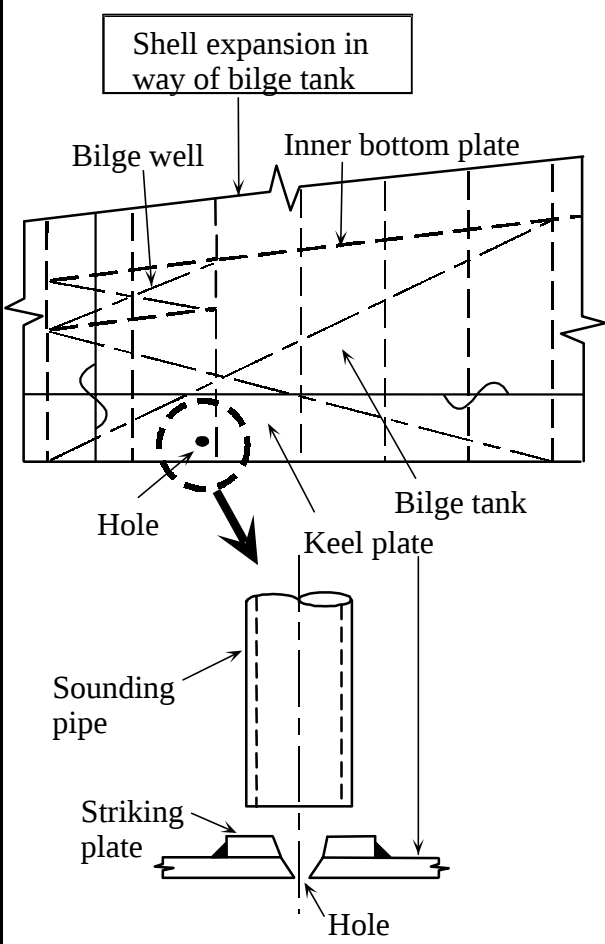
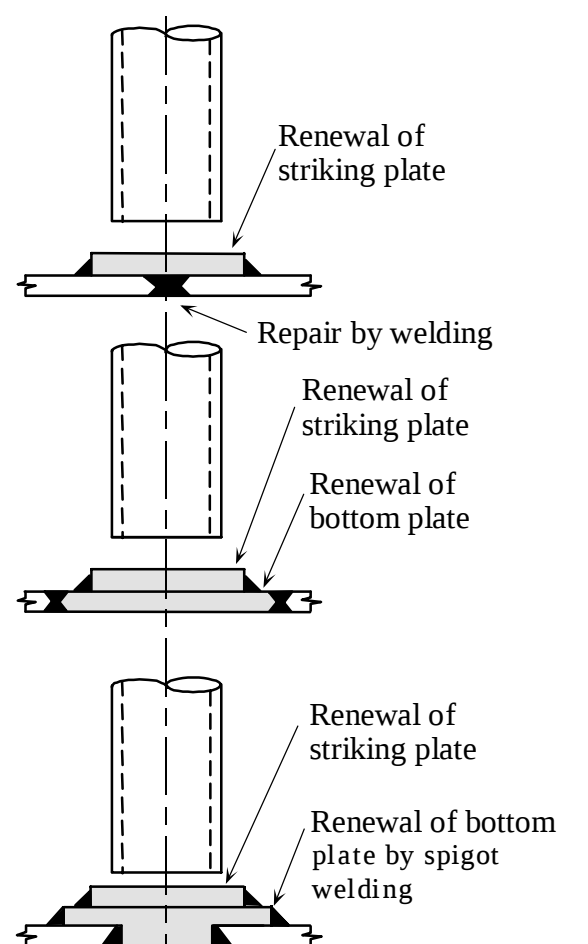
- 4.1.1** Where part of the structure has deteriorated to the permissible minimum thickness, then the affected area is to be cropped and renewed.

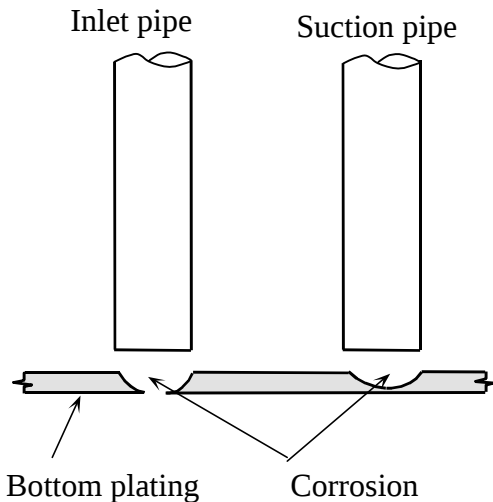
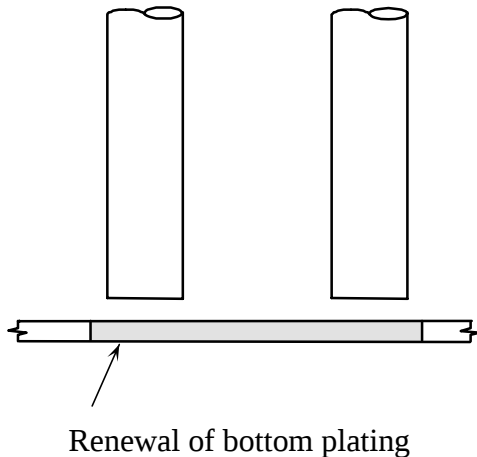
Repair work in double bottom will require careful planning in terms of accessibility and gas freeing is required for repair work in fuel oil tanks.

4.2 Fractures

4.2.1 For fatigue fractures caused by vibration, in addition to the normal repair of the fractures, consideration should be given to modification of the natural frequency of the structure to avoid resonance. This may be achieved by providing additional structural reinforcement, however, in many cases, a number of tentative tests may be required to reach the desired solution.

BILK CARRIERS	Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	Machinery and accommodation spaces	Example No.
Area 1	Engine room structure	1
Detail of damage Fractures in brackets at main engine foundation		
Sketch of damage  View A - A		Sketch of repair  View B - B
Notes on possible cause of damage 1. Vibration of main engine. 2. Insufficient strength of brackets at main engine foundation. 3. Insufficient pre-load bolts.		Notes on repairs 1. Fractures are to be veed-out and rewelded. 2. New modified brackets at main engine foundation. 3. Or insert pieces and additional flanges to increase section modulus of the brackets.

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	Machinery and accommodation spaces		Example No.
Area 1	Engine room structure		2
Detail of damage		Corrosion in bottom plating under sounding pipe in way of bilge storage tank in engine room	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Heavy corrosion of bottom plating under sounding pipe.		Notes on repairs 1. Corroded striking plating should be renewed. 2. Bottom plate should be repaired depending on the condition of corrosion. (Note) Repair by spigot welding can be applied to the structure only when the stress level is considerably low. Generally this procedure cannot be applied to the repair of bottom plating of ballast tanks in cargo hold region.	

BULK CARRIERS		Guidelines for Surveys, Assessment and Repair of Hull Structure	
Part 3	Machinery and accommodation spaces		Example No.
Area 1	Engine room structure		3
Detail of damage		Corrosion in bottom plating under inlet/suction/pipe in way of bilge tank in engine room	
Sketch of damage 		Sketch of repair 	
Notes on possible cause of damage 1. Heavy corrosion of bottom plating under the inlet/suction pipe.		Notes on repairs 1. Corroded bottom plating is to be cropped and part renewed. Thicker plate is preferable. 2. Replacement of pipe end by enlarged conical opening (similar to suction head in ballast tank) is preferable.	

Area 2 Accommodation structure

Contents

1 General

Figures and/or Photographs - Area 1	
No.	Title
Photograph 1	Corroded accommodation house side structure

1 General

Corrosion is the main concern in accommodation structure and deck houses of aging ships. Owing to the lesser thickness of the structure plating, corrosion can propagate through the thickness of the plating resulting in holes in the structure.

Severe corrosion may be found in exposed deck plating and deck house side structure adjacent to the deck plating where water is liable to accumulate (See **Photograph 1**). Corrosion may also be found in accommodation bulkheads around cutout for fittings, such as doors, side scuttles, ventilators, etc., where proper maintenance of the area is relatively difficult. Deterioration of the bulkheads including fittings may impair the integrity of weathertightness.

Fatigue fractures caused by vibration may be found, in the structure itself and in various stays of the structures, mast, antenna etc. For such fractures, consideration should be given to modify the natural frequency of the structure by providing additional reinforcement during repair.



Photograph 1 Corroded accommodation house side structure

Appendix 1 Criteria for Local Strength

1 For a ship constructed in accordance with CCS rules and the keel of which was laid before 15 January 1983, the renewed thickness of hull plating and structural members is not to be less than the value obtained by multiplying their as-built thickness and the relevant percentage shown in Table 1 below:

Table 1 The standards of corrosion and wastage of hull structural members constructed in accordance with CCS Rules and the keel of which was laid before 15 January 1983

Structural member	Minimum renewed thickness		
	Unrestricted service	Service category 1	Service categories 2 and 3
Strength deck, side and bottom shell	75%	70%	65%
Continuous longitudinal strength members and web frames	75%	70%	65%
Foundations of main engines, cranes and windlasses	75%	75%	75%
Other structural members defined in the Rules	70%	60%	55%

2 For a ship constructed in accordance with CCS Rules and the keel of which was laid on or after 15 January 1983, the renewed thickness of hull plating and structural members is not to be less than the value obtained by multiplying their as-built thickness and the relevant percentage shown in Table 2 below:

Table 2 The standards of corrosion and wastage of hull structural members constructed in accordance with CCS Rules and the keel of which was laid on or after 15 January 1983

Structural member	Minimum renewed thickness	
	$L \geq 90\text{m}$	$L < 90\text{m}$
① Strength deck plating, side shell, top strake, bilge strake, bottom shell, flat plate keel, inner bottom, continuous longitudinal bulkhead, hopper tank and topside tank plating.	80%	75%
② Main longitudinal continuous members, e.g. deck girders, hatch side girders, side girders, bottom girders, bulkhead girders, continuous hatch coamings.		
③ Main transverse members, e.g. side frame webs, deck transverses, double plate floors, bulkhead webs, watertight and oiltight transverse bracket plates.		
④ Transverse bulkhead plating in holds, upper and lower bulkhead stool sloping plating, watertight bulkhead plating in deep tanks.		
Other plating and members, e.g. deck within line of openings, deck longitudinals, side longitudinals, bottom longitudinals, inner bottom longitudinals, bulkhead longitudinals, face plates of frames, brackets of members	75%	70%
Note: For bulk carriers designed in accordance with the CCS Rules- and assigned the class notation of “Strengthened for Heavy Cargoes”, the minimum renewed thickness may be taken by multiplying their as-built thickness and 75%.		

- 3 Considering no specific and clear corrosion limit is defined in the current CCS Rules for interior members of peak compartment, in order to unify standards and avoid the application of different standards for corrosion limit due to understanding discrepancy, the Guidelines offer the clarifications of the corrosion standard for above-mentioned structural members. See Table 3 for more details.

Table 3.2A The standards of corrosion for additional structural members

Structural member	Minimum renewed thickness	
	$L \geq 90\text{m}$	$L < 90\text{m}$
Structural members of fore and stern peaks.	75%	70%

- 4 Regulations on the net thickness/corrosion allowance in non-CSR bulk carrier contracted for construction on and after July 1, 1998 during

4.1 Recently, the non-CSR bulk carriers contracted for construction on and after July 1, 1998 have successively entered the secondary special survey window. At the time of implementing inspection, the site surveyors found that many ships do not have evaluation documentation of URS12, 18, 21, some of which are transferred from other classification societies of IACS or surveyed by our classification society during the construction, causing great trouble to the site surveyors. As lack of assessment information, the surveyor cannot confirm the net thickness of structural members required by URS18, 21 and assess the thickness measurement results. Now according to the current actual situation and with reference of the uniform requirements and provisions of our classification society's standard, if we cannot get the net thickness values of corrugated bulkhead and hatch cover approved by Plan Approval Center, the corrosion limitation can be determined by use of the way of as-built thickness minus corrosion addition, which is shown as below:

4.2 URS18: this requirement is applicable to bulk carriers of 150m in length and above (excluding double skin bulk carriers not required by URS18.1) contracted for construction on or after July 1, 1998, which is with single deck, topside tanks and hopper tanks, intending to carry solid bulk cargoes having a density of 1.0 t/m^3 , or above, with vertical corrugated transverse watertight bulkheads. The net thickness value of corrugated watertight transverse bulkhead plating and structural members which are applicable to this requirement can be calculated by as-built thickness minus corresponding corrosion addition, and the corrosion addition is taken as 3.5mm. When the actually gauged thickness of the watertight corrugated bulkhead is less than $t_{\text{net}} + 0.5 \text{ mm}$, the renewal measure are to be taken and the renewal thickness is taken as as-built thickness; when the actually gauged thickness of the watertight corrugate bulkhead is within the range between $t_{\text{net}} + 0.5 \text{ mm}$ and $t_{\text{net}} + 1.0 \text{ mm}$, the corrugated bulkhead can be coated according to the requirements of coating manufacturer or annually gauged as an alternative to renewal.

4.3 URS21: this requirement applies to all bulk carriers, ore carriers and combination carriers, and are for all cargo hatch covers and hatch forward and side coamings on expose decks in position 1 as defined in International Convention on Load Lines, 1966.

For non CSR bulk carriers contracted for construction on and after 1 July 1998, the net thickness values of hatch covers are to comply with the requirements of IACS URS21.

For non CSR bulk carriers, ore carriers and combination carriers contracted for construction on and after 1 January 2004, the evaluation criteria for structural components of hatch coamings are to comply with requirements of IACS URS21.6.2 (Note: since IACS UR S21(Rev.3), the evaluation criteria of net thickness for structural components of hatch coamings of applicable bulk carriers, ore carriers and combination carriers are put forth for the first time).

The net thickness values of hatch covers and coaming stated in this requirement can be calculated by the as-built thickness minus corresponding corrosion addition t_s , specific value t_s is shown as below:

1) Hatch cover

For all structures (plating and secondary stiffeners) of single skin hatch cover, the corrosion addition t_s is to be 2.0mm.

For double skin hatch cover, the corrosion addition is to be:

- 2.0 mm, for roof and base plate;
- 1.5 mm, for internal structures.

For the plating of double skin hatch cover and for plating and stiffeners of single skin hatch cover, if the actually gauged thickness is less than $t_{net}+0.5\text{mm}$, the renewal measures are to be taken, the renewal thickness is the as-built thickness; as the actually gauged thickness is within the range between $t_{net}+0.5\text{ mm}$ and $t_{net}+1.0\text{ mm}$, the coating applied in accordance with the requirements of coating manufacture or annual gauging could be adopted as an alternative to renewal, the coating is to be maintained under “good” condition as defined in UR Z10.2.1.2.

For the internal structure of double skin hatch covers, thickness gauging is required when plating renewal is to be carried out or when this is deemed necessary, at the discretion of the surveyor, on the basis of the plating corrosion or deformation condition. If the gauged thickness is less than t_{net} value, the internal structure is to be renewed, and the renewal thickness is the construction thickness.

2) Hatch coaming

The corrosion addition of the structure of hatch coaming and coaming stays is to be 1.5mm.

When the actually gauged thickness is less than $t_{net}+0.5\text{ mm}$, the renewal measures are to be taken, when the actually gauged thickness is within the range between $t_{net}+0.5\text{ mm}$ and $t_{net}+1.0\text{ mm}$, the coating applied in accordance with the requirements of coating manufacture or annual gauging could be adopted as an alternative to renewal, the coating is to be maintained under “good” condition as defined in UR Z10.2.1.2.

4.4 URS12: this requirement applies to side structures of cargo holds bounded by the side shell only of bulk carriers constructed with single deck, topside tanks and hopper side tanks in cargo spaces intended to primarily to carry dry cargo in bulk, which are contracted for construction on or after July 1, 1998.

For the side frames of this ship, when the rule length of the ship is greater than/ equal to 90m, 20% of the as-built thickness of web is to be taken to determine the maximum wastage limit, and 25% of as-built thickness of flange is to be taken to determine the maximum wastage limit; when the rule length of the ship is less than 90m, 25% of the as-built thickness of web is to be taken to determine the maximum wastage limit, and 30% of as-built thickness of flange is to be taken to determine the

maximum wastage limit. If the thickness measurement indicates wastage in excess of wastage limits, it is to be renewed, and the renewal thickness is as-built thickness.

4.5 The measures mentioned above are to be taken to determine the net thickness value and thickness diminution, and these corrosion criteria are to be proposed on the Survey Planning Meeting (if any), if the ship-owners raise an objection, the ship-owner can submit assessment documentation of URS12,18,21 to Plan Approval Center of our classification society, and the Plan Approval Center will determine the net thickness value of relevant structural members after evaluation.